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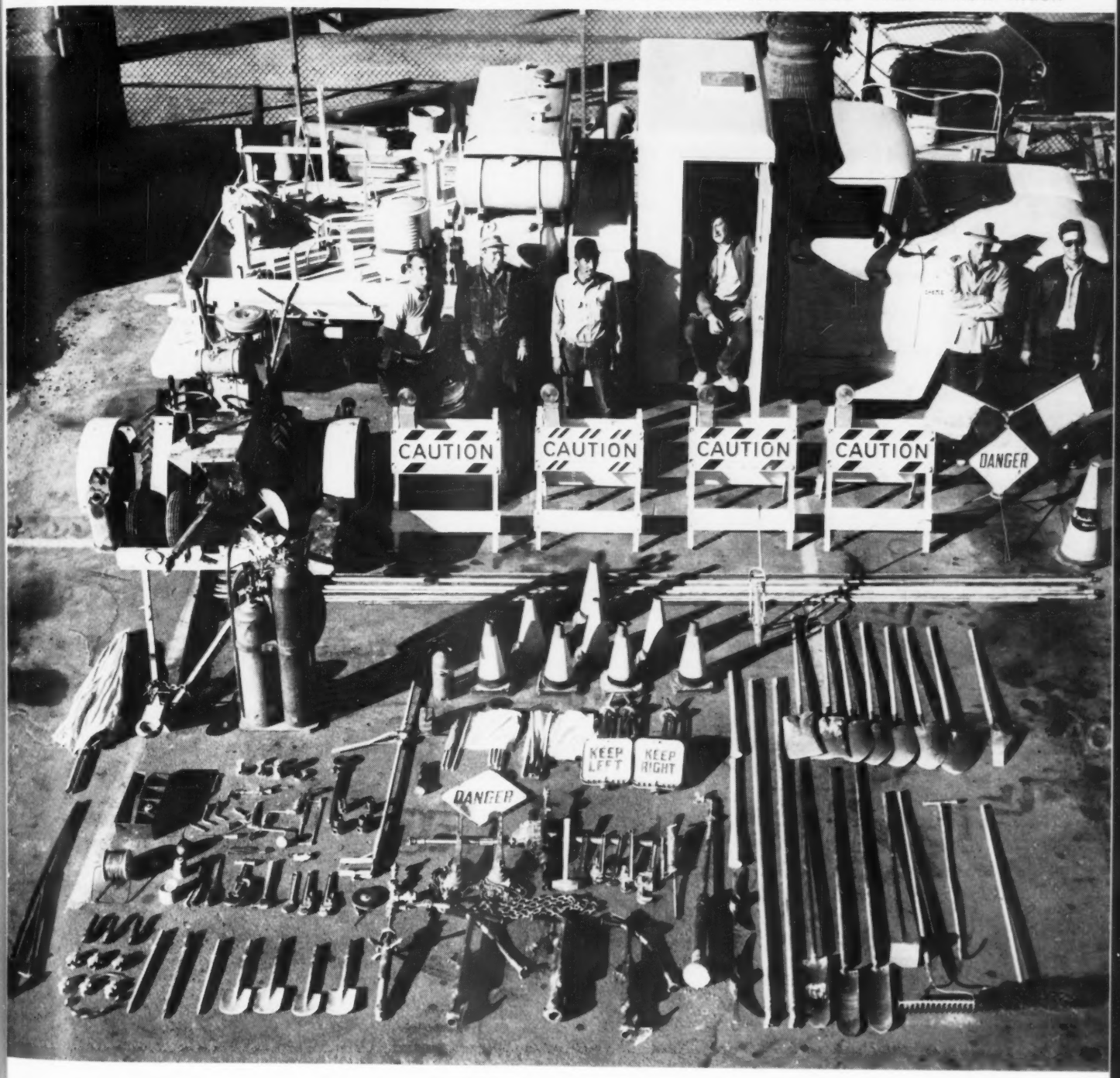

AMERICAN
Gas Journal
THE MAGAZINE OF GAS DISTRIBUTION

♦♦♦♦ *New Peak Shaving Plant*
Corrosion Inspection Methods
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MARCH 1961

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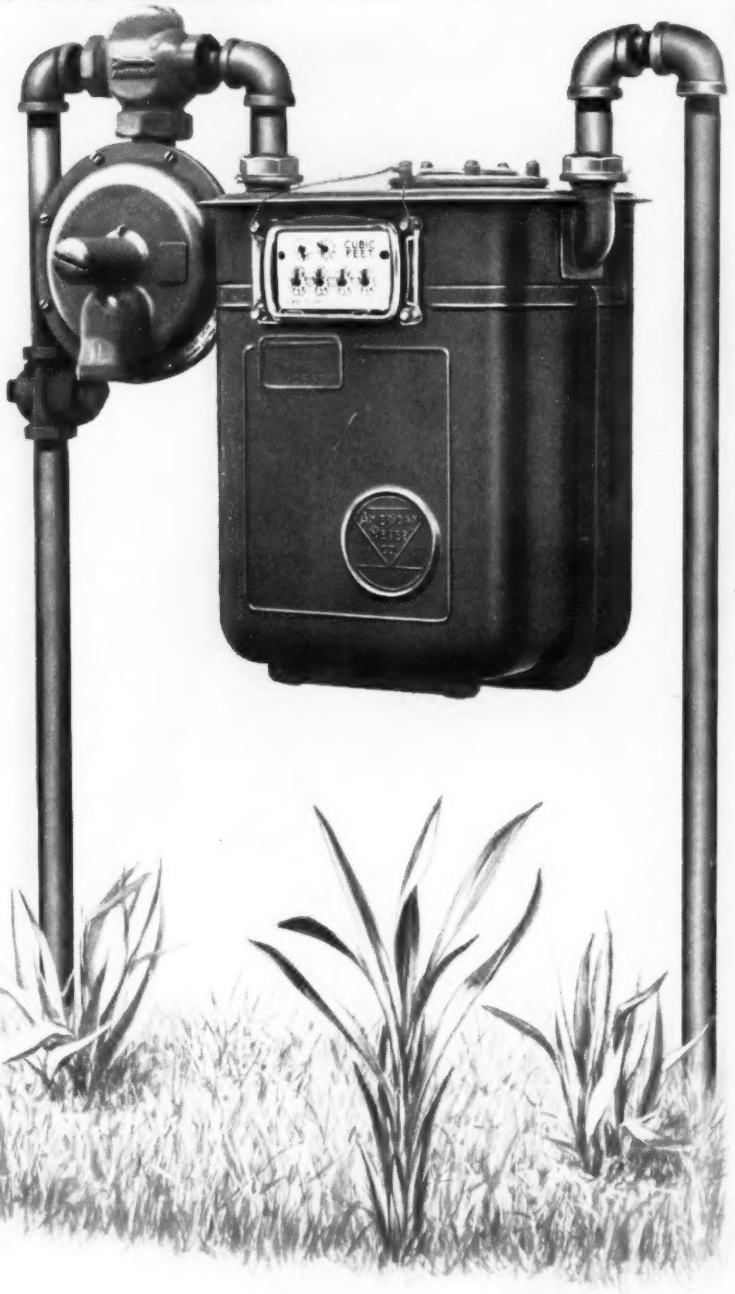

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PILOT LIGHTS

Men, Machines, and Mains

What does it take to build and maintain a gas distribution system? How much of what types of equipment are required? Offhand, these seem like simple questions to answer. These—and similar—questions are quite frequently asked around the AGJ shop . . . the inquirers are men in the gas distribution companies, engineering consulting firms, contractors, and men who sell equipment.

Some six months ago, AGJ's editors decided to embark on an extensive study of the industry based on an across-the-board survey of operating companies and distribution contractors, supplemented by data previously developed, and punctuated with on-the-spot interviews across the country of men in the companies and contracting firms about the equipment they use, how much they use, and when and why they replace it.

We were overwhelmed by the response to our survey questionnaire. The men we asked to provide us data are busy men . . . *yet 73% of them took time to dig into company records and accurately complete a seven-page questionnaire!* And another 25% provided some data or explained why they could not participate and offered to respond at a later date. A 98% response is really terrific . . . and points up the cooperation that has helped make the gas distribution industry great.

The magnitude of the survey is exceptional . . . companies of all sizes, small ones of a few thousand customers up to the giant ones of over a million are represented . . . and geographically, all sections of the U. S. are represented . . . and the survey includes straight gas distribution companies, the gas departments of combination gas and electric utilities, and the distribution divisions or departments of "integrated" gas companies.

Contractors who install gas mains and services came through with flying colors, too . . . some one-third of all the distribution spreads operating in the nation are represented . . . by size and by geographic location.

What's really remarkable about our "Construction Equipment Survey" is that 1) nothing like it had ever before been attempted; 2) the extensiveness of the study, and 3) the results . . . which point out that the gas distribution industry is also a major factor in the construction equipment business.

Want to know more about it? Turn to page 22 of this issue.

American Gas Journal
THE MAGAZINE OF GAS DISTRIBUTION

VOLUME 188 MARCH 1961 NUMBER 3

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M C F

NEWS HILITES OF THE INDUSTRY

End use of natural gas can be considered by the FPC in matters relating to interstate transportation of the gas, the Supreme Court decreed in late January. The court upheld FPC's authority to consider both end use of gas and the effect of its price on producers when it rules on a direct sale by a producer to an industrial consumer when the sale of the gas is to be transported by an interstate gas pipeline. Under the law, FPC cannot regulate such sales directly —or the price involved—but it can deny certificates to potential transporters. The court's decision upset a lower court ruling that would have allowed Transcontinental Gas Pipe Line Corporation transport up to 50,000,000 cu ft per day from Texas gas fields to New York City for Consolidated Edison Company for use in firing boilers for generating electricity.

Fate of the "Enchilada Inch" project by Tennessee Gas Transmission Company, its subsidiary—California Gas Transmission, and Southern California Edison Company may hinge on the Supreme Court decision in the Con Ed-Transco case. The project—involving a line from south Texas gas fields through northern Mexico and delivery to Southern California Edison for use as boiler fuel—is in a state of regulatory flux. California's PUC is presently hearing Edison's request to import the gas. TGT has asked the FPC to either give it a certificate for the short Texas line or disclaim authority to do so. Southern California gas utilities point out that they can't afford to lose their load and, besides, can supply Edison with sufficient gas. The FPC is expected to consider not only the end-use and price aspects, but also give weight to what effect the "Enchilada Inch" might have on health of other interstate gas pipelines serving the California market.

Old Sol may be gas' newest competitor. Two MIT research engineers, C. D. Engebretson and N. G. Ashar, at the winter annual ASME meeting, reported on a test house in Lexington, Massachusetts, where solar energy supplied 46% of the total heat requirements of the home . . . saving up to 60 cents per day over conventional heating equipment. Using the solar energy system, a room temperature of 73 to 75 F was maintained constantly. A solar heat collector was used to heat water for a hot-water heating system. At all times, said the MIT engineers, there was enough solar energy stored to keep the hot water at a 110 F level, but additional conventional heat was needed to heat water for washing chores, etc. The house used in the tests was a two-story frame building with seven rooms, two baths, and an entry hall.

Despite what EEI says in its national consumer magazine ads, gas is a lot safer than electricity, according to annual estimates of the National Fire Protection Association. Only 3½ percent of all building fires in the U. S. in 1959 were attributed to gas and gas appliances. Electricity accounted for nearly 14.7 percent. Of a total 883,300 estimated fires, gas is listed as the cause of only 31,600. Electricity is listed as the cause of 122,900 fires, nearly 4 times more. NFPA, a non-profit, voluntary membership safety organization, compiles its annual estimates of the nation's fire causes and losses from reports of Federal, state, and local fire authorities. Of total losses of $1,083,000,000 estimated for 1959 as result of fires, gas accounted for only 2.6 percent and an estimated $28,500,000; electrical causes accounted for $193,220,000—approximately 17.5 percent.

Prohibition of "dump" sales of natural gas in industrial markets (especially as boiler fuel for electric generating plants) has been advocated by National Coal Association president Stephen F. Dunn as a means of aiding depressed coal mining areas. The NCA prexy told a subcommittee of the Senate Banking and Currency Committee, holding hearings on various depressed area bills, that Congress could relieve economic distress in many surplus labor communities by freeing the coal industry of "competitive inequities." He also attacked residual oil imports and called for a cutback in the oil import program.

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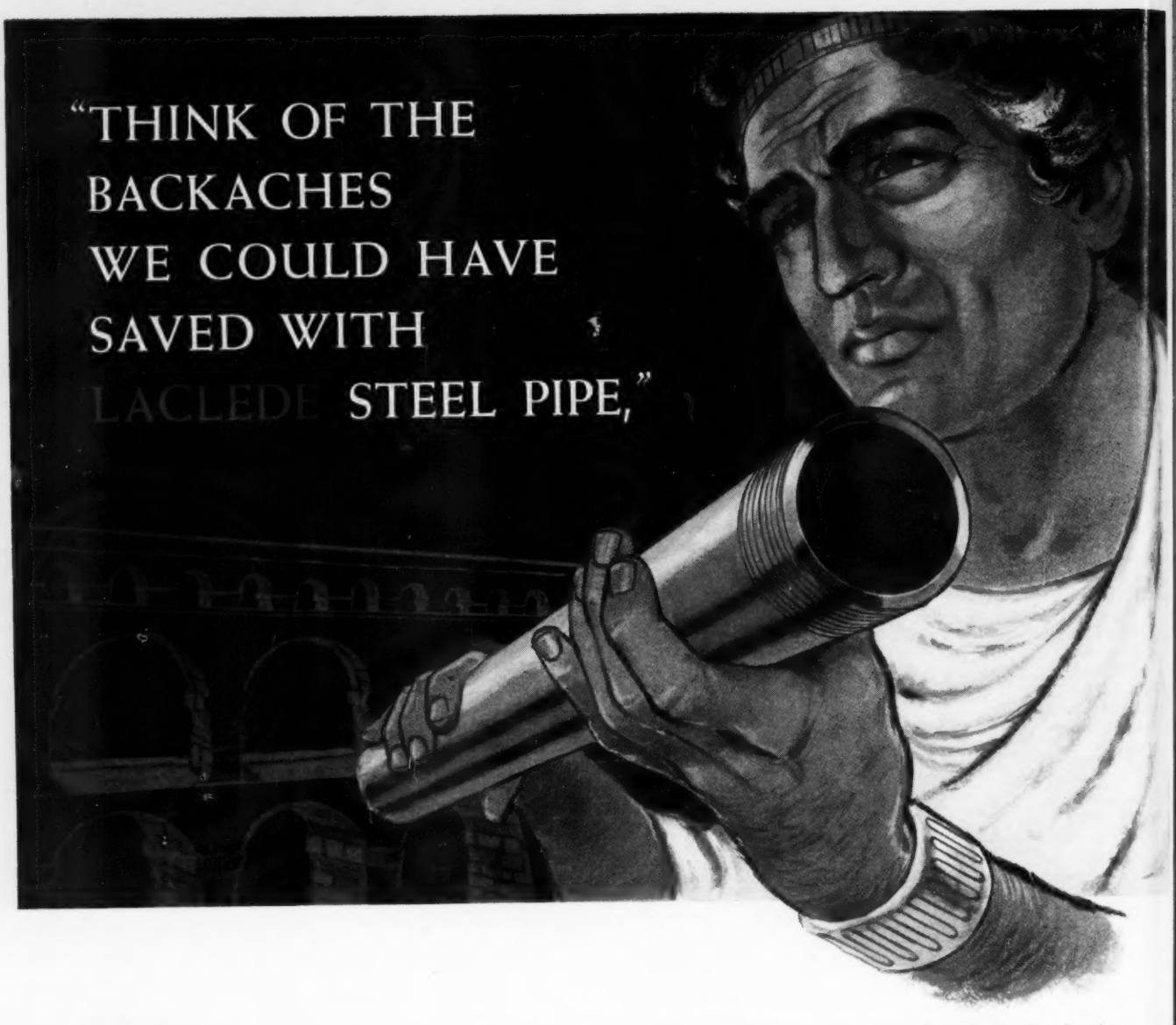

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Calendar

OF COMING EVENTS

March

13-17 National Association of Corrosion Engineers, annual conference, Hotel Statler, Buffalo, New York.

15-17 NGAA 40th annual convention, Baker and Adolphus Hotels, Dallas, Texas.

16-17 SGA distribution management, Dinkler Plaza Hotel, Atlanta, Georgia.

16-17 NEGA annual meeting, Statler Hilton Hotel, Boston, Massachusetts.

20-22 A.G.A. general management section annual conference, Francis Marion Hotel, Charleston, South Carolina.

27-28 Mid-West Gas Association annual meeting and convention, Sheraton-Fontenelle Hotel, Omaha, Nebraska.

April

4- 6 A.G.A. research and utilization conference, Sheraton Cleveland Hotel, Cleveland, Ohio.

6 Pennsylvania Gas Association, fourth annual 1-day distribution conference, Tally Ho Inn and Hotel, Valley Forge, Pennsylvania.

6- 7 PCGA distribution conference, Biltmore Hotel, Los Angeles, California.

7 Maryland-District of Columbia Utilities Association spring conference, Lord Biltmore Hotel, Baltimore, Maryland.

9-13 ASME Oil & Gas Power conference and exhibit, Jung Hotel, New Orleans, Louisiana.

10-21 American Welding Society, International Institute of Welding, annual convention and welding exposition, Sheraton-Atlantic, New York, New York.

11-13 A.G.A. sales conference on industrial and commercial gas, Prince Edward Hotel, Windsor, Ontario, Canada.

13-15 GAMA annual meeting, Boca Raton, Florida.

16-19 A.G.A.-EEI national conference of electric & gas utility accountants, The Chase-Park Plaza Hotels, St. Louis, Missouri.

17-18 PCGA commercial-industrial sales conference, Los Angeles area.

18-20 Southwestern Gas Measurement Short Course, University of Oklahoma, North Campus, Norman, Oklahoma.

20-21 Indiana Gas Association annual convention, French Lick, Indiana.

24-26 Southern Gas Association, annual convention, Roosevelt and Jung hotels, New Orleans, Louisiana.

28 NGAA Oklahoma regional meeting, Lake Murray Lodge, Ardmore, Oklahoma.

30-May 2 Independent Petroleum Association of America, midyear meeting, Roosevelt Hotel, New Orleans, Louisiana.

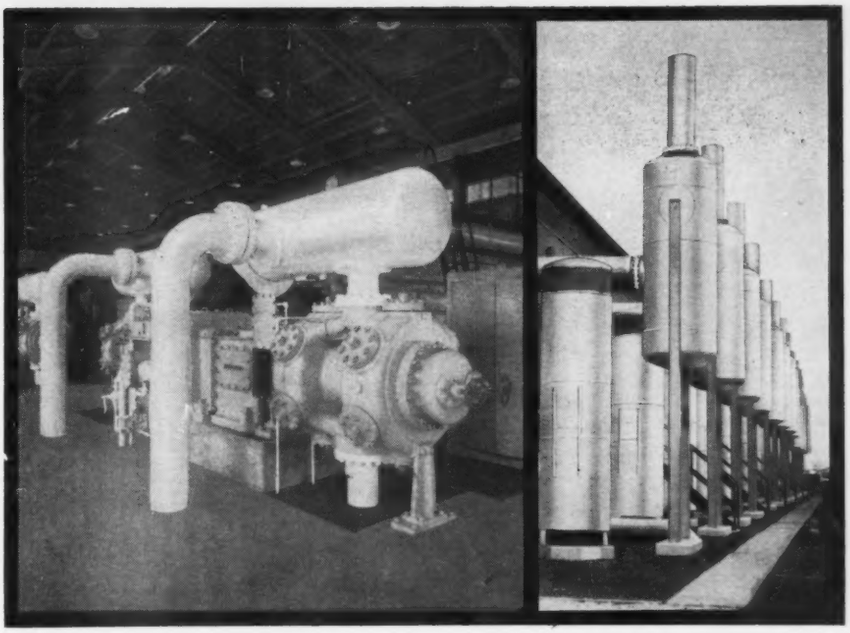
May

8-12 PCGA commercial gas sales school, Villa Hotel, San Mateo, California.

8-12 A.G.A. operating section distribution and production conference, Sheraton Hotel, Philadelphia, Pennsylvania.

14-18 National Fire Protection Association annual meeting, Detroit, Michigan.

15-17 A.G.A. mid-west regional gas sales conference, Edgewater Beach Hotel, Chicago, Illinois.



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Construction Equipment Survey

of gas distribution companies and distribution contractors

Intensive industry-wide survey of construction/maintenance equipment used by companies and contractors reveals who uses what, how much they use, how often they replace it

Dean Hale, Editor

How much of what types of construction/maintenance equipment is used in the gas distribution industry — by operating companies and by contractors? And how are they used?

To find out, the editors of AMERICAN GAS JOURNAL in the past six months have conducted an extensive, intensive study of operating gas distribution companies and of contracting firms engaged in the installation of gas distribution mains and services to determine exactly what they use and how they use it.

We wanted to know, in detail:

- The sizes, ratings, styles, and quantities of all construction equipment items used, item-by-item, for installing and maintaining mains and service lines.
- If contractors and operating companies used similar equipment for the same purposes.
- If there were certain equipment items in use that are not generally known in the industry.
- What criteria are used for determining when equipment should be replaced and how often it is replaced.
- Who buys or specifies equipment in both operating companies and in contracting firms.

Study Results

Only a thorough study of the gas distribution industry could produce the results the editors felt necessary. Such a task involved a large scale survey of over 1300 distribution companies of all sizes, plus over 500 contracting firms.

Survey results were supplemented by personal contacts with many operating company and contractor executives, engineers, and supervisory personnel to obtain "on-the-job" information.

Data in this report is based on exceptionally large and representative samples of all types and sizes of both operating companies and contractors.

Represented in the report are:

1. **Gas distribution companies** having 16,197,203 customers—46.3% of the nation's total at the end of 1960; company sizes range from very small to very large.

2. **Gas distribution contractors** having a total of 334 spreads—33.0% of the average total in the nation; contracting firm size ranges from small one-spread companies to large, multi-spread organization.

No Canadian or foreign companies or contractors are included.

Publication of all the data and evaluations of such an extensive study would not be possible in one article. For the reader's benefit, this report highlights findings and gives brief explanations.

GAS DISTRIBUTION COMPANIES

Gas distribution companies bury a great deal of pipe each year. During 1960, they laid more than 19,300 miles of pipe. In footage, this is far more than the combined gas transmission-crude products pipeline industry total. In pipe tonnage, the figures are quite close.

1960 figures on pipe installed for gas distribution mains (12,100 miles):

49.44% of the pipe was 2-in. diameter or smaller
41.89% of the pipe was 3 to 8-in. diameter
6.99% of the pipe was 10 to 16-in. diameter
1.68% of the pipe was over 16-in. diameter

Of the 7200 miles of service lines installed during 1960:

95.03% was 1½-in. diameter or smaller
4.97% was 2-in. diameter or larger

The companies included in this report:

Serve 16,197,203 customers — *46.3% of the industry's December 31, 1960, total.*

Added 411,179 new customers in 1960 — *53.47% of the industry's total additions in 1960.*

Installed 9224.7 miles of new mains — *76.3% of the industry's 1960 total.*

Installed 4806.4 miles of new services — *66.7% of the industry's 1960 total.*

For each new customer added in 1960, gas distribution companies surveyed installed:

118.3 ft of new main
61.7 ft of new service line

Equipment Utilization

Gas distribution companies use a great deal of construction/maintenance equipment for building and maintaining their extensive distribution systems. Here are some "average" figures:

1 tractor (wheel- or track type) for every	13,433 customers
1 trencher of some type for every	18,243 customers
1 large backhoe for every	80,597 customers
1 crane for every	79,803 customers
1 pneumatic tamper for every	3,960 customers
1 air compressor for every	5,327 customers
1 pneumatic tool of some type for every	949 customers
1 unit, gasoline engine-driven equipment, for every	11,514 customers
1 pipe tool of some type for every	5,782 customers
1 electronic pipe locator for every	7,380 customers
1 pipe tapping and/or plugging device for every	5,141 customers
1 unit of stopping equipment (bags, etc.) for every	2,891 customers
1 unit road boring equipment for every	16,364 customers
1 pipe pusher for every	29,725 customers
1 welding generator (a-c or d-c) for every	13,171 customers
1 oxy-acetylene welding set for every	9,168 customers
1 passenger vehicle (automobile) for every	1,950 customers
1 truck of some type for every	1,087 customers
1 semi-trailer of some type for every	14,647 customers

Following are details on various types of equipment owned and operated:

Tractors

Of the companies surveyed, 89% use wheel-type tractors and 59.8% use track-type tractors. Of the total number of tractor units operated, 76.1% are wheel-type and 23.9% are track-type.

Track-type tractors in "bantam" sizes (under 50 hp) comprise 60.7% of the total owned by gas distribution com-

panies, with 33.7% in the 51 to 100-hp range, 4.5% in the 101 to 150-hp range, and only 1.1% rated over 151-hp. Approximately 5.3% of the track-type tractors are of the special "pipelayer" design.

Most popular **attachment** for track-type tractors is the *dozer blade* — 50.7% of the track-type tractors are so equipped. Other attachments are: *Sidebooms* — 26.5%; *trenchers* — 25.0%; *front-end loaders* — 17.0%; *winches* — 20.4%; *top-mounted "swing" cranes* — 8.6%; and *hydraulic backhoes* — 5.0%.

Wheel-type tractors in the 31 to 60-hp range represent the bulk of the total units — 63.6%. Only 17.5% of the tractors are under 30-hp, while 17.8% are in the 61 to 100-hp group, and only 1.1% are over 100-hp.

Almost all (87%) of the wheel-type units are standard *industrial 4-wheel tractors,* usually fitted with various attachments. *Shovel-loader tractors* represent 7.6% of the category total, and some of these are equipped with attachments such as hydraulic backhoes or sidebooms. The other 5.4% of the category is comprised of *integral tractor-air compressor units,* some of which also are fitted with various attachments.

Most popular **attachment** for wheel-type tractors is the *front-end loader* — 62.8% are so equipped. *Hydraulic backhoes* run a close second — 55.3% of the wheel-type tractors are so equipped. Other attachments include *dozer blades* — 29.6%, and *trenching attachments* — 17.4%. Also used are *forklifts, winches, brooms, snow plows, vertical augers, rock drills, "brush hogs," gang mowers,* and *rakes.*

Trenchers

Wheel-type trenchers are used by 58.4% of the companies, while 30.6% of the companies employ *track-mounted ladder or vertical boom type trenchers,* and 34.8% have *truck-mounted ladder or vertical boom type units.*

Only 22% of the wheel-type trenchers are capable of digging ditch wider than 18-in. or deeper than 5 ft., while 23% of the track-mounted ladder or boom units can dig wider or deeper than 18-in. by 5 ft. Only 7.0% of the truck-mounted ladder or boom units will dig over 18-in. wide or 5 ft. deep.

Trenchers mounted on jeeps are used by 29.2% of the companies, while 52.8% use *small portable chain-type trenchers,* and 30.6% of the utilities own *tractor-mounted trenching equipment.* The last three items are used principally for service lines and very small mains.

Backfilling

Equipment used by distribution companies for backfilling of trenches and bellhoes:

23.6% own and use *crawler-mounted backfillers*
13.9% own and use *maintenance (motor) graders*
5.2% own and use *ditch padding machines*

Other backfilling practices:

84.8% use *front-end loader on wheel-type tractor*
20.9% use *front-end loader on track-type tractor*
54.2% use *dozer blade on wheel-type tractor*
48.0% use *dozer blade on track-type tractor*

Other equipment used to lesser degree includes pull-blades on wheel-type tractors, dozer or pull-blade on jeep, front-end loader on truck, and pull-blade used with crane.

Tamping

Pneumatic tampers are used by 98.7% of the companies; 16.7% use *gasoline-powered tampers;* 30.2% use *self-propelled, heavy-duty tampers* (also used as paving breakers), and only 2.87% use *sheeps-foot rollers* for compacting ditch fill. *Pavement rollers* are used by 15.3% of the companies in making road repairs (compacting backfill and roadbed sub-base and base).

Who Installs Mains and Services?

Company forces install about one-half the mains laid each year by the nation's gas distribution companies; contractors install the other half. A few companies install all of their mains and services, a few contract all of their construction. The vast majority, however, utilize their company forces the year around and contract major projects to specialized gas distribution contractors.

The following tables provide a summary of "contract vs. company force" construction practices across the nation:

INSTALLATION OF MAINS

Size of Main	Feet of Pipe Installed by Company Forces	Feet of Pipe Installed by Contractors
2-in. and under	55.2%	44.8%
3-in. to 8-in.	46.8%	53.2%
10-in. to 16-in.	31.2%	68.8%
Over 16-in.	19.5%	80.5%
Total, all sizes mains	**49.4%**	**50.6%**

INSTALLATION OF SERVICES

Type of Service	Feet of Pipe Installed by Company Forces	Feet of Pipe Installed by Contractors
Residential (1½-in. or smaller)	69.8%	30.2%*
Commercial and Industrial (2-in. and larger)	76.3%	23.7%

*Companies report that plumbing and/or piping firms install 5.2% of the total feet of pipe; this is service line piping on customer's property, extending from meter to residence. None reported on industrial and commercial services.

Other Excavating Equipment

Backhoes (other than tractor-mounted hydraulic backhoes) are used by 45.9% of the gas distribution companies; of these units, 61.2% are self-propelled units (97% are under 1 cu yd capacity); another 31.3% are carrier-mounted (also 97% are under 1 cu yd capacity), and only 7.5% in use are crawler-mounted, all under 1 cu yd capacity.

Draglines and Clamshells. Only 5.5% of the companies have dragline buckets and only 13.9% use clamshell buckets. Of both types, all are under 1 cu yd capacity.

Cranes. Approximately 70.9% of the companies use a crane of some type. About 32% of the utilities use *truck-mounted units,* 20.9% use *hydraulic cranes mounted on flat-bed trucks,* 20.0% use *self-propelled cranes,* 11.1% use *crawler-mounted units,* and 13.9% use a *self-propelled hydraulic crane.*

By capacity, 56.5% of the cranes used by the gas distribution companies are under 3-ton capacity; 31% are 3 to 10-ton, and 21.5% are over 10-ton capacity.

Air Compressors

Use of **air compressors** by gas distribution companies is universal — 90.4% of the companies use *reciprocating* types, 87.6% use *rotary* types, and only 5.6% use *centrifugal* compressors.

Of the total air compressor units in use, 52.3% are reciprocating, 46.8% are rotary, and less than 1% are centrifugal.

By capacity, the air compressors are divided almost evenly in two classes — 49% are 105 cfm or under capacity, 50% are rated at 110 to 210 cfm, and about 1% are rated over 210 cfm.

Most popular method of mounting air compressors is the trailer — 55% of the units are of this type; 38.4% are truck-mounted, and 1.7% are tractor-mounted. The remainder are skid-mounted or hand-carried portable units.

Pneumatic Tools

The following tabulation indicates utilization of air-powered tools by companies:

Tool	% of Co's	Tool	% of Co's
Rock drills	76.5%	Saws	26.4%
Wagon drills	4.2%	Backfill tampers	98.7%
Paving breakers	98.7%	Concrete vibrators	12.5%
Grinders	59.8%	Sump pumps	72.3%
Diggers, spade-type	86.2%	Concrete saws	8.3%
Chipping hammers	69.5%	Other & Miscellaneous	4.2%
Wire brushing units	43.1%		

Gasoline Engine-Driven Tools & Equipment

Portable sump pumps are used by 86.2% of the gas distribution companies; 75.1% of the companies also use *portable electric generators* (86% of these units have 5-kw or less output); 18.1% of the companies use small engine-driven *chain saws* for clearing brush and small trees; 15.3% have *large skid-mounted (or similar) pumps* used for hydrostatic testing and draining ditches, and 30.6% have engine-driven *portable concrete saws.*

Pipe Tools

A variety of **pipe tools** are used by the companies: 44.5% use *pipe saws;* 63.9% use *cutting and beveling machines;* 44.5% use small manual or hydraulic *pipe benders;* 11.1% use *large benders,* mounted on trucks, tractors, or skid-mounted. Very few companies — 4.2% use *pipe straighteners.*

Line-up clamps are used by 73.7% of the companies, and of the clamps in use, 98% are manual external types, only 2% are manual internal.

Pipe Coating and Wrapping

Very few gas distribution companies do any pipe coating or wrapping — those that do generally do it in their own pipe yards. Over-the-ditch coating and wrapping is rarely done. Only 11.1% of the companies have *cleaning and priming machines,* and only 7% have *coating and wrapping machines.* Manual *tape wrapping machines* are owned by 18.1% of the companies, while 5.6% have powered tape wrapping equipment. Other equipment — such as machines for applying cold dope — are owned by 8.3% of the companies.

Other Construction/Maintenance Equipment

Electronic pipe locators are used by 83.4% of the companies.

For detecting flaws in pipe coating, 63.9% of the companies have **holiday detectors,** and 16.7% of the companies use *Pearson-type holiday detectors.*

Dope kettles are standard equipment for 51.4% of the companies.

Manhole and vault ventilators (blowers or exhausters) are used by 44.5% of the companies.

Almost all of the companies use some type of **pipe tapping and/or plugging equipment.** *Stopping equipment,* such as bags, plates, and mechanical stoppers are used by 61.2% of the companies.

Road boring equipment of some type is owned and used by 83.2% of the companies. Approximately 71.2% of the total units are *pneumatic drive,* 22.5% are *direct drive,* and 6.2% of the units are *hydraulically driven.*

Only 18.1% of the companies use **clay augers,** while 61.2% use **pipe pushers,** and 23.6% use **pipe squeezers and reopeners** (a relatively new item of equipment).

Well-pointing equipment is owned by 5.6% of the companies. Approximately 23.6% of the utilities employ **portable electric tools** of some type, usually ½-in. drills, grinders, and buffers.

Welding Equipment

Nearly all companies — 96½ — own some type of **arc welding generator.** Specifically, 84.8% of the companies have *direct current generators* and 29.2% have *a-c units.* Of the total types in use, 78.6% are d-c and 21.4% are a-c. Favorite method of mounting is on a truck — 48.3% — while another 41.5% are trailer-mounted nad 7.0% are skid-mounted.

Oxy-acetylene equipment is used by 91.7% of the companies.

Transportation Equipment

Automobiles and trucks of every size and type are found in the fleets of vehicles operated by the gas distribution companies, ranging from compact cars to 10-ton trucks.

Only 23% of the companies lease **passenger** cars and of the total number of passenger vehicles operated, only 13% are leased.

Favorite body style is the 2-door sedan — 34.27% of the vehicles are in this classification; 4-door sedans are second in popularity with 25.82%; compact 2-door style—10.66%; station wagons — 4.91%; compact 4-door sedans — 4.35%; compact station wagons — 1.13%, and other body styles account for 18.86% of the total.

Interestingly enough, 71% of the companies own compact cars, but the smaller vehicles comprise only 16.2% of the total number of passenger vehicles operated.

Replacement of passenger vehicles is decided by three criteria — age, condition, mileage. Very few companies have a hard-and-fast policy on replacement, but most replace passenger cars at 5 years or 60,000 miles.

Gas distribution companies own most of their **trucks** — 88.7% of the total operated with only 11.3% leased. Only 15% of the companies lease trucks . . . and in most cases the leased equipment is of specialized design.

Based on *gross vehicle weights,* 70.94% of the vehicles operated are in the light category (up to 10,000-lb); 24.14% are in the medium category (10,001 to 19,500-lb), and 4.92% are considered heavy (over 19,500-lb.)

By body styles, the most popular units are trucks with service bodies — 35.3% of the total. Pickups are next —

27.0% of the total, followed by trucks with crew bodies—11.3% of the total; panel trucks — 8.2%; flat bed and/or stake body trucks — 6.1%; dump trucks — 3.5%; highway tractor units — 1.1%; jeeps — 0.6%, and other miscellaneous styles — 6.9%.

Crew buses, used for personnel transportation to and from job sites, are owned by very few companies — only 9.7%.

Mobile home trailers used for field offices are owned by 19.5% of the companies.

Semi-trailers of some type are owned by 79.2% of the companies. Of the total semi-trailer units operated, 33.3% are flat beds, 26.6% are pipe or pole type, 12.3% are "low boy" type, 2.6% are vans used as shops, 1.1% are vans used as offices, and 1.2% are general purpose vans. The remaining 22.8% represents a variety of other specialized types.

CONTRACTORS

Contracting firms engaged in installing gas distribution mains and service lines are "big business." During 1960, gas distribution contractors installed 50.6% of the more than 12,100 miles laid. They also installed 25% of the 7200 miles of service lines laid.

The larger the size of the main, the more likely a distribution contractor will install it. Contractors, during 1960, installed 44.8% of the 2-in. diameter and smaller mains; 53.2% of the 3 to 8-in. mains; 68.8% of the 10 to 16-in. mains, and 80.5% of the mains over 16-in. diameter.

Of the slightly more than 500 gas distribution contractors in the U. S., 52.6% are engaged full-time installing mains and services and 47.4% considered "part-time" who 78% derive between 50% and 99% of their revenue from contract gas distribution work. These 500-plus contractors worked for an average of three different gas distribution companies during 1960, and in the past five years, have worked for an average of six different gas distribution utilities.

There are approximately 50 distribution contracting firms with 3 or more spreads; the remaining 450-plus have either 1 or 2 spreads. While the total number of spreads in the nation varies seasonally, the average total is approximately 1000. Respondents to AGJ's survey account for 334 spreads, or approximately 33.4% of the total. This sample represents an excellent cross-section, ranging from small, single spread firms to large, multi-spread organizations. The average spread requires about 20 employees; the range is 18 to 35 personnel, depending on contractor policy and job requirements.

Some pertinent facts about contractors:

- 92% use wheel-type tractors with hydraulic backhoes and front-end loaders for excavation and backfilling.
- 42% use wheel-type tractors with sidebooms for handling pipe.
- 48% use track-type tractors with hydraulic backhoes.
- 76% use track-type tractors with sidebooms for pipe handling.
- 92% report that most of the pipe they install is yard coated and wrapped.
- 37% report they have equipment available for coating and wrapping pipe (including machines for wrapping).

What equipment is used by the "average" distribution spread? Actually, there is no such thing as an average distribution spread . . . because locale, job requirements, and personal preferences all affect the equipment requirements of an individual spread. There is, however, a "hard core" of major equipment needed by the "average" spread . . . this is shown in the accompanying table.

Equipment used by the contractors varies in relative quantities—but not necessarily in size—from that used by the gas distribution companies. Gas utilities often require highly specialized machinery and vehicles that the contractor eliminates from his equipment inventory; if he needs such an item, he rents or leases it. Here's what the distribution contractors* own and operated:

Tractors

Track-type tractors. Approximately 52.5% of the tractors used by distribution contractors are track-laying or crawler types. While installation of gas distribution mains and services does not require the huge, heavy equipment used in cross-country pipeline construction, contractors use somewhat heavier tractor equipment than distribution companies because contractors do more of the larger pipe installation.

Approximately 36.9% of track-type tractors used by contractors are under 50-hp; 39.0% are in the 51 to 100-hp range; 17.8% are 101 to 150-hp units, and 6.3% are over 151-hp. Approximately 17% of the track-type tractors used are special design "pipelayer" units.

A variety of attachments are used with track-type tractors:

- 43.6% are equipped with *sidebooms*
- 31.6% are equipped with *dozer blades*
- 23.4% are equipped with *winches*
- 11.7% are equipped with *hydraulic backhoes*
- 10.5% have top-mounted *"swing" cranes"*
- 7.8% have *front-end loaders*
- 4.7% have *trenching-attachments*
- 19.7% have *arc-weld generators* mounted on them.

Other attachments required for specialized functions are used by a few contractors.

Here are some of the major items of equipment and tools used by an average distribution spread for laying gas mains and service lines:

- 3 Tractors, wheel and/or track type
- 6 Attachments: Front-end loader, Sideboom, Hydraulic Backhoe, Dozer Blade, Trencher, Winch
- 1 Trencher, large, wheel- or ladder-type
- 1 Backhoe, truck-mounted or crawler-mounted, often a combination unit.
- 1 Crane, truck-mounted or self-propelled
- 2 Air compressors (often one is leased)
- 7 Pneumatic Tools, including 2 paving breakers and 2 backfill tampers, plus other types as required
- 1 Portable sump pump
- 1 Portable electric generator (where portable electric hand tools are used)
- 1 Pipe Cutting & Beveling machine
- 1 Pipe bender, manual or hydraulic
- 1 Electronic pipe locator
- 1 Holiday detector
- 1 Dope kettle
- 1 Pipe tapping and plugging machine
- 1 Boring machine
- 3 Clay augers
- 2 Arc welding units (often 1 is leased)
- 2 Oxy-acetylene welding sets
- 1 Passenger vehicle
- 4 Trucks (1 pickup, 1 with crew or service body, 1 flat-bed or stake, and 1 other type)
- 1 Semi-trailer (pipe, pole, flat bed, etc.)

*This report covers only gas distribution contractors engaged basically in the installation of gas distribution mains and service lines. Pipeline contractors, who install gas transmission lines, crude oil, and refined products pipelines, and crude and gas gathering lines, are reported in the March 1961 issue of *Pipeline Engineer*, companion publication of *American Gas Journal*.

Wheel-type tractors. Some 47.5% of the tractors used by distribution contractors are in this category, which includes the familiar 4-wheel tractor (85% of the category total), shovel-loaders (8% of category total), and integral tractor-air compressor units (7% of category total).

Most of the wheel-type tractors used by distribution contractors are in the small or medium size brackets—16.9% are under 30-hp, 54.1% are in the 31 to 60-hp range, 18.9% are 61 to 100-hp, and 10.1% are over 100-hp in size.

Wheel-type tractors are used for a great variety of jobs by the distribution contractor and their versatility is increased by the number of different **attachments** with which they can be employed. Multiple applications are quite popular. Wheel-type tractors are equipped as follows:

49.8% have *front-end loaders*
48.5% have *hydraulic backhoes*
19.9% have *dozer blades*
15.4% have *sidebooms*
8.3% have *winches*
4.8% have *trenchers.*

Other attachments used include **fork lifts, pull blades, mowers, vertical augers,** and **rock drills.**

Trenchers

Four principal types of trenchers are used by gas distribution contractors—*large wheel or ladder type* (66.5% of the total); *trenchers mounted on jeeps* (9.7%); *trenchers mounted on tractors* (10.0%) and *small, portable chain-type trenchers* (13.8% of the total).

In the large trencher category, 75% of the total are wheel-type trenchers. Most of the wheel-type trenchers used (73%) will dig up to 18-in. wide by 5 ft deep. Ladder type (or vertical boom) trenchers mounted on tracks account for 18% of the total (59% will dig up to 18-in. wide by 5 ft deep) and truck-mounted ladder types (or vertical booms) account for another 7.0% (with 89% of them used for trench up to 18-in. wide and down to 5 ft deep).

Compared with the operating gas distribution companies, contractors have a greater number of larger-size trenchers, due to the fact that they install a majority of the industry's larger gas mains.

Other Excavating Equipment

Excavating equipment used (in addition to trenchers and hydraulic backhoes mounted on tractors) includes the larger *backhoes, draglines, clamshells,* and *cranes.*

Crawler-mounted **backhoes** are the most popular—60% of the units used by distribution contractors—followed by carrier-mounted (28%), and self-propelled (12%). Small capacity units predominate—91% of all backhoe units are under 1 cu yard in capacity.

Clamshells and **dragline buckets** are almost entirely of less than 1 cu yd capacity.

Cranes. Truck-mounted cranes are the most popular—accounting for 36.0% of the total, followed by hydraulic cranes mounted on flat-bed trucks—22.8% of the total; crawler-mounted, 19.2%; self-propelled, 15.5%; and self-propelled hydraulic cranes, 6.5%. Two size ranges predominate—38% are under 3-ton capacity, 43% are in the 3 to 10-ton range, and 19% are rated over 10-ton capacity.

Backfilling Equipment

Most gas distribution contractors have either a *motor grader* or a *crawler-mounted backfiller* in their inventory—but not necessarily one for every spread. The industry ratio is about 3 backfiller units for every motor grader in use.

Backfilling practices vary from those used by the distribution companies:

75% of the contractors use a dozer blade on a track-type tractor;
45% use a dozer blade on a wheel-type tractor;
48% use a front-end loader on a track-type tractor, and
76% use a front-end loader on a wheel-type tractor.

Tamping Equipment

Pneumatic tampers are commonly used by distribution contractors for compacting backfill. There is, usually, at least one pneumatic tamper for each distribution spread and nearly half of the spreads have two units.

Not as common are **gasoline-powered tampers,** which are found on about 15% of the spreads.

Self-propelled, heavy-duty tampers (which also double as paving breakers) are used by approximately 63% of the contractors.

Very few **sheeps-foot type roller tampers,** narrow in width and used to compact backfill in the ditch are utilized by contractors.

Pavement rollers, used to compact backfill and street fill and to make road repairs, are owned by 87% of the contractors.

Air Compressors

Every distribution spread has one **air compressor** and nearly half of them have two units. Of the units owned, 66.3% are of the *reciprocating* type, 31.2% are *rotary* units, and only 2.5% are *centrifugal.* By capacity, 43.5% of the air compressors are rated at 105 cfm or less, 46.0% are in the 110 to 210 cfm range, and 10.5% have capacity greater than 210 cfm.

Trailer-mounted air compressors comprise 78.5% of the total, truck-mounted units, 16.1%, tractor-mounted units 4.3%, and the remaining 1.1% includes skid-mounted units, portable hand-carried units, and some miscellaneous types.

Pneumatic Tools

Paving breakers, backfill tampers, spade-type diggers, and *rock drills* are the most common pneumatic tools found in use by distribution spreads. The average spread has seven air-powered tools, of which two are paving breakers and two are spade-type diggers.

Other pneumatic tools, in order of importance, include *chipping hammers, grinders, sump pumps, wire brushing machines, saws, concrete vibrators,* and *wagon drills.* All types of pneumatic tools are found in the contractor's inventory, and equipment is often moved from spread to spread as job requirements change.

Gasoline Engine-Driven Tools and Equipment

Portable sump pumps and **large skid-mounted pumps** are used to drain water from ditches and bellhoes. Some two-

thirds of the spreads have these items as standard equipment.

Portable electric generators are found in about one-third of the spreads; however, every contractor owns at least one unit, and most have two units. Most common are small generators with output up to 5-kw (80% of the total).

Chain saws, used to clear brush and small trees, are used by all contractors. About one-third of the spreads are equipped with them.

Portable concrete saws are considered essential by 92% of the contractors, who own at least one unit and sometimes two units, depending on the total number of spreads the contractor has in the field.

Pipe Tools

Pipe cutting and beveling machines are found in 98% of the spreads. **Pipe benders**—small manual or hydraulic—are used by 32% of the spreads. **Large benders,** truck- or tractor-mounted, are used by 25% of the spreads. **Pipe saws** are used by less than half (40%) of the contractors.

Practically all of the **line-up clamps** in use are of the manual external type, with an average of 3 to 4 clamps per spread. A few manual internal clamps are used, and very few hydraulic or pneumatic internal clamps are employed.

Pipe Coating and Wrapping

As pointed out previously, 92% of the contractors report that most of the pipe they install has been yard coated and wrapped. The contractor has only field joints and valve installations to coat and wrap—and this is done manually.

To handle those jobs where pipe has not been yard coated and wrapped, 37% of the contractors report they have equipment on hand for coating and wrapping pipe. These contractors have an average of two **cleaning and priming machines** and one **coating and wrapping machine.** They also have an average of one manual or powered **tape wrapping machine.** A few have equipment for cold applying dope.

Welding Equipment

Every spread has at least one **arc-welding generator;** approximately one-third of the spreads have two units. Direct current generators comprise 80% of the total; the other 20% are a-c.

Favorite mounting for generators is on trucks — 66% mounted in this fashion—another 31% are trailer-mounted and the remainder are on skids or mounted on tractors.

At least two **oxy-acetylene welding sets** are found, on the average, in every distribution spread.

Other Equipment and Tools

Equipment already enumerated totals hundreds of items but there are still others that a distribution contractor must have to do a thorough job. Included are:

Electronic pipe locators—found in one-third of the spreads.

Holiday detectors—used by two-thirds of the spreads. A few also use *Pearson-type holiday detectors.*

Dope kettles—70% of the spreads use them to keep coating materials hot.

Pipe tapping and plugging machines—standard equipment on two-thirds of the spreads.

Road boring equipment—owned by all contractors, found in use by two-thirds of the spreads. Of types used, 33% are direct-drive, 53% are pneumatic drive, and 14% are hydraulic drive.

Pipe pushers—used by approximately 10% of the contractors.

Clay augers—used by one-third of the contractors. Of those using this equipment, about half of them use large numbers of units.

Pipe squeezers and re-openers—a comparatively new item, used by only 5% of the contractors.

Transportation Equipment

Favorite **passenger vehicle** of contractors is the *4-door sedan;* 50% of the automobiles operated are of this body style. Another 23% are *2-door sedans,* followed closely by *station wagons*—21%.

Contractors apparently do not like *compact vehicles*—less than 1% of the vehicles in use are compacts.

Most contractors own their passenger vehicles — only 22% of the vehicles used are leased.

Replacement of passenger vehicles occurs generally at 3 to 4 years of age. Condition of the vehicle and mileage operated are equally considered as criteria for replacement. The average mileage of vehicles at time of replacement is approximately 60,000 miles.

Contractors also own most of their **trucks**—85.5%—with only 14.5% of the total trucks operated being leased.

Gross vehicle weights of contractors' trucks indicate contractors operate heavier truck equipment than distribution companies. Light trucks (to 10,000 lb) comprise 51.7% of the total operated by contractors, while 33.0% are in the medium category (10,001 to 19,500 lb), and 15.3% are heavy-weights (over 19,501 lb).

Predominant *body style* of contractors' trucks is the pickup (30.8%). Other styles and percentages of the total include panel trucks, 3.1%; jeeps, 4.6%; vehicles with crew bodies, 4.1%; vehicles with service bodies, 10.1% flat-beds and/or stake bodies, 15.2%; dump trucks, 11.6%; highway tractors, 11.7%, and other styles (such as special equipment water tanks, concrete mixers, wreckers, etc.), 8.8%.

Approximately two-thirds of the contractors own a **crew bus** for transporting personnel to job sites.

Contractors also make good use of **mobile home trailers,** utilizing them for *field offices.* Most contractors own one of these, and about one-third have two or more units.

Semi-trailers of all types are found in contractors' equipment inventories. Types include: van, general purpose — 11.2% of the total; van—used as office, 8.5%; van—used as shop, 6.3%; pipe or pole, 31.4%; flat bed—19.3%; and "low boy" (used for transporting heavy equipment such as tractors, trenchers etc.)—23.2%.

EQUIPMENT REPLACEMENT

When should equipment be replaced? What criteria apply? Generally, both operating companies and contractors apply the universal yardsticks — age, condition, maintenance cost, depreciated value, and actual value.

Distribution companies generally replace construction/maintenance equipment on a condition and/or cost-of-upkeep basis rather than age. The more a piece of equipment is used, the more likely it will be replaced at an early date. Tractors, wheel or track-type, for example, are replaced every 4 to 8 years, with the average at 5 years. Trucks are replaced anywhere from 3 to 8 years, the average about 6.5 years. The heavier the truck, the longer it is kept. Truck condition is a far more important criterion. Automobiles, on the average, are kept for 5 years or 60,000 miles before being replaced.

Backhoes, cranes, trenchers, air compressors, welding rigs, and similar equipment have an average service life of 5 to 8 years, with some heavy equipment lasting for 10 years before replacement. Condition and maintenance cost play a large role. Small tools, such as pneumatic tools and pipe tools, are replaced more frequently — anywhere from 2 to 5 years.

Gas distribution contractors replace equipment more frequently because their equipment sees harder service. Tractors and trucks are replaced every 3 or 4 years. Attachments for tractors usually are kept 4 or 5 years. Cranes, backhoes, air compressors, welding rigs, trenchers, etc. are replaced anywhere from 3 to 6 years, depending on condition, upkeep, etc. A number of contractors report their equipment inventory "turns over" completely every 5 years. * * *

360-Degree picture window of the Chemosphere "sky house" provides virtually unhampered view of the San Fernando Valley.

— *Photos courtesy Southern California Gas Company.*

Space Age Sky House Goes All Gas

From the Ventura Freeway, you can see it perched on the side of a hill. At that distance, it appears to be something designed for Space Age living . . . a sort of flying saucer with its landing gear down.

The unique residence, named "Chemosphere," carries a spatial and chemical connotation in keeping with its out-of-this-world appearance. Erected high in the Hollywood Hills, the sky-high house incorporates novel design and new-type construction methods that may be auguries of things to come.

Ultramodern in structural design, the Chemosphere is ultramodern in interior furnishings, too. It's an all-gas house . . . with built-in gas range top, oven, refrigerator, and washer-dryer, plus all-year gas air conditioning for climate control. Natural gas is supplied by Southern California Gas Company.

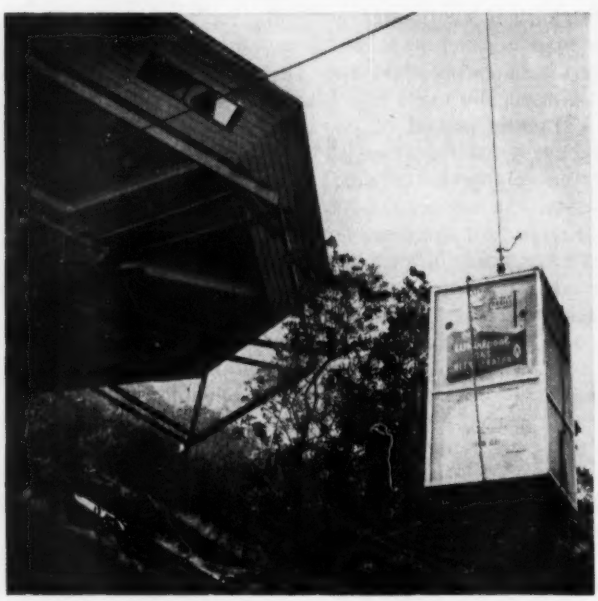
Built on top of a 5-ft thick reinforced concrete column sunk into a steep hillside and rising 30 ft above the ground, the Chemosphere is octagonal in shape, with a 360 degree picture window.

Construction of the futuristic—but perfectly functional—home represents the imagination, efforts, and know-how of the owner-builder Leonard Malin, architect John Lautner, and the Chem Seal Corporation of Los Angeles, sponsor of the singular project. Basic idea in building the 2200 sq ft house on top of a concrete column was to provide a footing stable enough to withstand earthquakes, landslides, high winds, and other disturbances of nature and man.

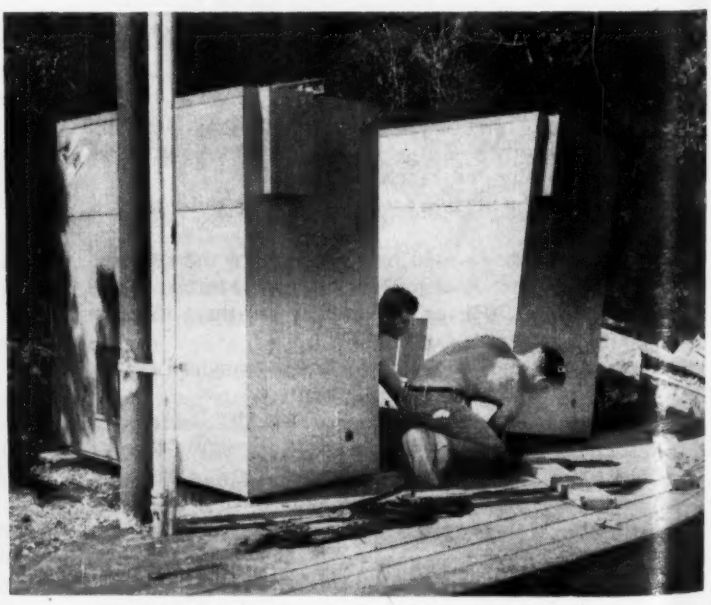
Steep ascent to the sky-house from the winding roadway below is negotiated by a four-passenger cable car.

Main living space of the Chemosphere occupies 1400 sq ft, including kitchen, bar, dining space, and fireplace alcove, under an octagonal ceiling dome and skylight. There are four bedrooms, two bathrooms, a laundry, and a sewing room.

The extraordinary arrangement of the sky-house, with its all-around picture window, affords the owner—a 28-year-old electronics engineer—and his family a breath-taking panoramic view of city lights, freeways, and the burgeoning San Fernando Valley in the distance. * * *



Operation airlift. New gas refrigerator makes airy ascent to Chemosphere, built 30 ft above the ground. The octagonal residence features complete gas kitchen, gas washer-dryer, gas air conditioning. All appliances had to be raised by special hoist.



Climate control. Twin Arkla gas air conditioning units provide year-around comfort for the unusual house. Southern California Gas Company assisted in installing the appliances in the Chemosphere.

Corrosion Inspection Methods in Practice

Herbert C. Van Nouhuys, *Consulting Editor*

CORROSION INSPECTION METHODS were begun and have evolved through the years for the purpose of determining the extent of corrosion damage so that optimum methods of mitigation could be applied.

Application of mitigative measures were begun as a necessity—the alternative being shut-down, highly expensive repairs, loss of product, bodily hazard, and operation at reduced profit or even loss.

It appears then, that after a plant has been constructed and maintenance begins, corrosion inspection methods, as far as the corrosion aspect of maintenance is concerned, are the first link in the all important chain of profitable free enterprise.

The Leak Record

The story of the evolution of *Corrosion Inspection Methods* begins with the days when labor and materials were relatively cheap and Mother Nature cooperated in the inspection process by staining the plains with splotches of crude oil and assailing the ears and olfactory glands with the hiss and odor of natural or manufactured gas.

Any linewalker possessed of the normal senses of sight, sound, and smell was qualified to carry out this initial inspection method. This plan of location of hot spots from leak records, followed by application of cathodic protection at leak locations left no doubt either of accuracy of location or effectiveness of cathodic protection There are those who still maintain this to be the optimum method for certain non-critical bare lines, pointing out that 85 to 95% of a line will not develop leaks anyway and the remaining 5 to 15% corrosive areas are now well-defined and protected, and leaks are practically nil. Also, many pits will not develop into leaks until after the economic life of the line has run its course.

By quick detection in suspicious areas, loss of product is kept to a minimum, and repair is accompanied by anode installation, which saves digging part of a hole twice. No anodes are wasted and most effective use of anodes is achieved. This fundamental method allowed thousands of miles of bare pipe lines to remain in service and the cost of spot protection paid for itself many times over.[1,2,3,4]

This, however, is the one method not advocated by corrosion engineers today, who feel that the risk involved is not justified, and that newer methods and experience have reached a point of reliability which holds overprotection to a minimum for no greater cost.

Test Hole Method

When management learned that a corrosion engineer could actually mitigate corrosion, it then demanded that he obtain a crystal ball, predict where the next leak would occur, and prevent its occurrence.

Being the logical man that he is, and unable to obtain a crystal ball, the corrosion engineer simply embarked on a test hole program, often digging 6-ft bell-holes at suspicious locations such as creek crossings, low marshy areas and adjacent slopes, road ditches, cinder fills, and at changes in soil composition. By recording pit depths and numbers of pits per foot, and correlating data with adjacent test hole data, cathodic protection could be applied to the most serious areas and many leaks were thus prevented.

It was not long, however, until leaks showed up near test holes that had passed muster. It was found that a board, or soft rock, or lump of clay in hard contact with the pipe would cause pitting, or possibly no visual evidence was present, yet a short distance from a good test hole, a leak would occur.

Corrosivity varies widely even in a given soil type and a large number of observations are necessary.[5] Bureau of Standards studies show that while some soils are more corrosive than others, corrosion occurs in all soils, but not necessarily for the same reason.

Many varying combinations of at least a dozen factors influence pitting . . . for example—*potential difference, resistivity, contact resistance, moisture, temperature, films, polarization, pH, differential aeration, oxygen diffusion, stray currents, and bacteria.*

Cost of test holes gradually becomes higher than their efficiency warrants, and justification for digging is fortified by first making soil resistitvity tests, or line current or potential surveys, with the idea that as correlation is obtained, the faster, less expensive, instrument method can be relied upon and hence substituted.

Soil Resistivity Methods

Several engineers reported such good correlation between soil resistivity and pitting and leaks that this method soon became very popular.[6] Soil resistivities were measured usually by *Shephard Canes* or a *4-terminal Megger or Vibroground,* using the *Wenner 4-electrode Method.*

It is also possible that some obtained samples from pipe depth and used a soil box tester. The canes give a reading on the very small sample between their usual 8-in. space rods and consequently an ample number of readings are taken to assure a representative picture. The canes should be placed at pipe depth to give greatest accuracy. Single cane instruments are now on the market such as the *Collins* and *Associated Research,* which speed up the operation, but read a still smaller sample.

The Wenner Method involves a surface reading of resistance between four equally spaced rods that, when multiplied by the spacing between two rods and a constant, 191.5, gives average resistivity to depth equal to rod spacing.

The *Columbia Rod,* though never fully developed or widely used, was an attempt to build a single rod that would read not only soil resistivity, but other factors in corrosion such as potential of metal with respect to an adjacent electrolyte, and film formation as a result of polarization—shown by decreased current through a sensitive milliammeter. This is mentioned to emphasize that 30 years ago the need for a device to give a more complete analysis of corrosion activity was recognized.[7]

A *radio balance method* using a radio transmitter and receiver of the pipe locator type, mounted at each end of a wooden rod, has been found useful in locating boundaries between soils of low resistance. This is a very rough method applicable only in certain localities. By calibrating signal over a soil of known resistivity, change in tone can be correlated with soil of lower or higher resistivity.[8]

Test cells developed and/or improved by Putnam, Denison, Hickling, Darnielle, Muller, and Williams-Corfield, and others, have shown many interesting and important characteristics of single soil samples. The *Nipple and Can Test* used by the latter, which measures the weight loss of a steel nipple immersed in a nearly water saturated soil sample for 24 hours, has met with reasonable success in California soils. Most of the success of correlation is due to the large number (8000) of samples taken.[11-16]

Regardless of the method used, the engineer who applies himself will learn to understand the shortcomings of his method and instruments and how to allow for them. For example, a rough check on the megger for 3-ft spacing would be to average soil box samples from 1, 2, and 3-ft, and to check a *Cane,* immerse it in a solution that has also been tested with a soil box sample.

To determine how far apart readings should be taken in a particular soil, study in detail one or more representative sections. If your plan calls for magnesium anode design for a short bare line, you will no doubt take closer readings than for a long coated line in fairly uniform soil.

A bare 8-in. line in northwest Florida was undergoing a leak repair when it was noticed that a dark brown marl strata was distinctly and abruptly adjoined by a white Attapulgas Clay at the leak. These were soil box tested at 1000 and 100,000 ohm-cm respectively, and when placed side by side in a beaker with identical steel electrodes in each, produced a 0.1-v potential with current flow from the marl to the clay. Resistivities of 20,000 to 100,000 within a few feet are not uncommon in the Southeast and although these are considered very high in the Southwest, it is suggested that this condition could be as serious as a variation of 2,000 to 10,000 in the Southwest providing other factors of pH, aeration, moisture, soil pressure, etc., were also considered.

To give corrosion engineers everywhere a common ground of understanding when discussing soil resistivities, a table of Soil Resistivity Classification is proposed, as shown in Fig. 1.

SOIL RESISTIVITY CLASSIFICATION

RANGE IN OHM-CM	CLASS
0-1,000	VERY LOW
1,000-5,000	LOW
5,000-10,000	MEDIUM
10,000-25,000	HIGH
25,000-100,000	VERY HIGH
100,000-1,000,000	ULTRA-HIGH
1,000,000-INFINITY	SUPER-HIGH

Fig. 1.

Because resistivity *per se* is not always the controlling factor in corrosion, but rather a combination of many factors—which result in corrosion currents—it is the thinking of many engineers today that a better inspection method is to measure the potentials that cause the currents, directly, rather than the factors that tend to produce them.

Pipe to Soil Potentials

The P/S method usually involves the use of a copper-copper sulphate half cell to provide a connection to the soil, while connection to the structure may be by test lead or probe rod. In corrosion testing, high resistance contacts should always be avoided, or at least accounted for.

When using a probe rod, hitting the bare pipe a second time, or rotating under pressure may give a different value. Experience here is the best teacher. Using two probe rods about 3-ft apart is one check that will avoid gross errors such as are possible with rod resting on mill scale or a stone.

High contact resistance between electrode and soil, soil and pipe, and soil resistance itself, must be compensated for by use of either a high resistance voltmeter, a potentiometer voltmeter, or a vacuum tube voltmeter.

A series of megger readings along a bare pipe between pipe and a copper sulphate electrode 300-ft from the pipe showed about 1% exceeded 3000 ohms. A 3000 ohm external resistance will cause an 0.6% error in a 500,000 ohm/volt meter, a 3.0% error in a 100,000 ohm/volt meter, and a 6.0% error in a 50,000 ohm/volt meter. Larger errors would result on a well coated pipe.

There are several inspection procedures used, one of the most popular being the use of a 500-ft test lead and placing the electrode at 25 to 50-ft intervals. Longer intervals usually result in skipping too high a percentage of short anodic cells. This requires probing to the pipe only once every 500-ft.

Another variation giving the same result is the *Soil-to-Soil Surface Potential Method* using two copper sulphate electrodes, leapfrogging at similar intervals, and adjusting the initial pipe to soil potential reading for each successive point by adding or subtracting the millvolt rise or drop between electrodes, and checking against a pipe to soil reading at proper intervals. These methods are based on the not infallible logic that current flows in the pipe toward an anodic or discharge point, and in the soil away from an anodic point.

Sometimes, however, current in soil flows in the same direction, also flows from bottom to top of pipe are not uncommon. By plotting data, potential vs. distance, in the first quadrant, peaks represent current reversals in the soil, which in turn indicate the coming together of currents in the pipe with consequent discharge.[17,18]

Correlation of data with actual pipe condition indicates this method to be 60 to 80% effective in locating either deepest pits or areas of greatest number of pits. A sharp peak is often no more indicative than an elongated plateau, either of deepest pits or number of pits per foot, and inspection of valley areas occasionally reveals deep and numerous pits.[19]

This method can be said to be a general indicator of corrosion activity and, like all other methods, must be analyzed and interpreted by an engineer experienced in its use and in the particular soils involved.

The fact that increasing oxygen supply, or aeration, sends iron potentials in the anodic direction—while increasing pH from neutral into the alkaline range does the reverse—is partially responsible for the lack of better correlation. It is not difficult to visualize several combinations of aeration, pH, moisture, soil pressure, etc., that would

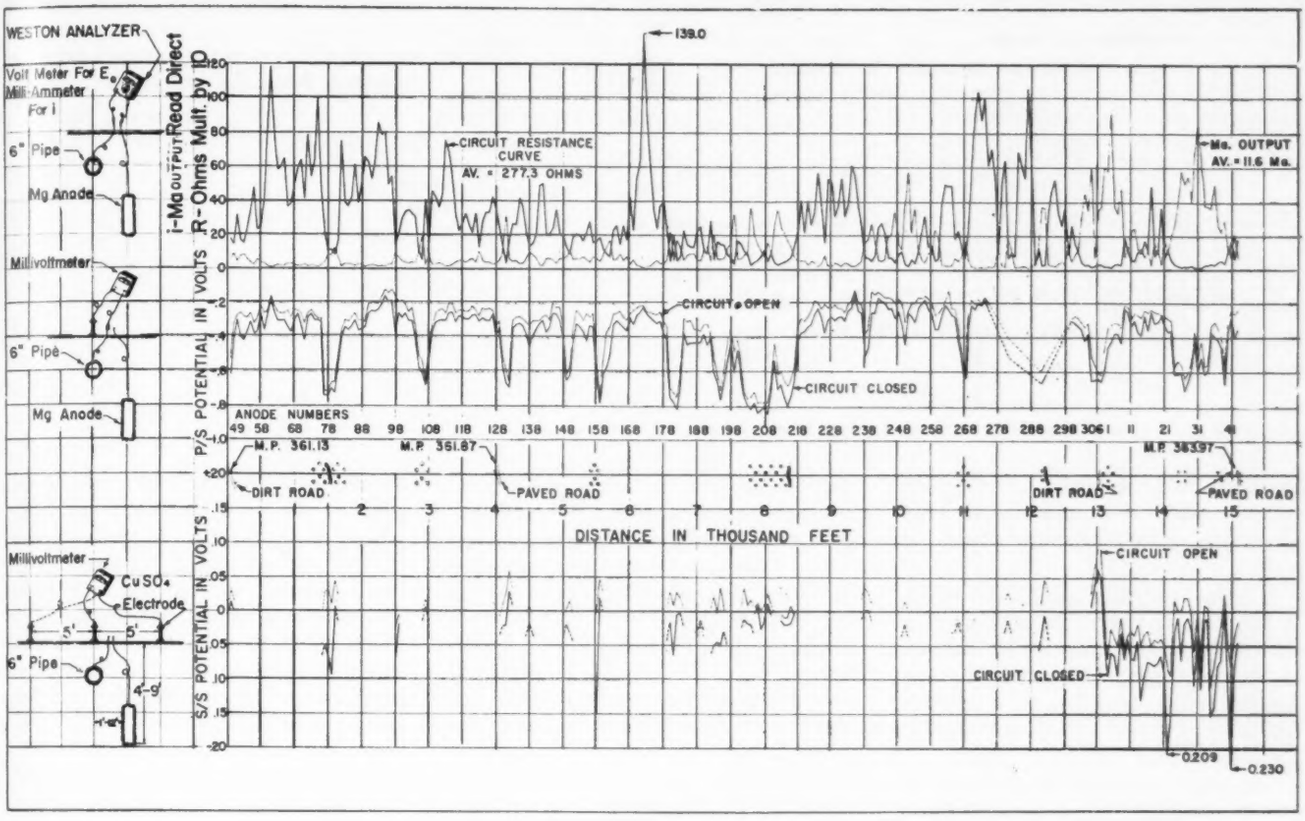


Fig. 2.

give varying corrosion intensities for the same pipe to soil potential.[20]

Another variation in procedure often used as a check at anodic points is the placement of one electrode over the pipe and the other at right angles and approximately 5-ft out. After reading the millivolt drop, this outer electrode is placed 5-ft out on the other side of the pipe to obtain an average, or to detect the degree of teluric currents present. This test was made standard procedure on one line,[21] for obtaining data at leak sites, and in every case where it was possible to get within several feet of the leak clamp location, a positive reading was evident.

Although cathodic protection design methods and criteria do not come within the scope of this discussion, it is pertinent to note that this test was not satisfied in suppressing anodic spots when the remote electrode criterion of 0.3-v. lowering of potential was not being met. When an 0.3 v. change to a remote electrode did accrue at an anodic spot, the 2-electrode test gave suppression in over 90% of the tests. A high resistance, center zero voltmeter with a 50-mv scale is excellent for this work.

A test in 1952[22] comparing pipe-to-soil potentials with this 2-electrode method at 50-ft spacing over 2.84 miles, showed not only the 14 dips in the curve below –0.6-v, as being anodic, but about six additional minor dips that ordinarily would not be so considered. This test is believed more sensitive, also more time consuming. It is particularly helpful in checking out and adjusting a newly designed system to assure suppression of anodic areas at electrical centers between rectifiers. A plot of these data is shown in Fig. 2.

Long Line Current Measurement

Before choosing this method the engineer should assure himself by spot checking with the 2-electrode test for example, that his line is not afflicted with the short concentration cell type of corrosion for which the potential survey would be preferable. Thousands of miles of pipe have been surveyed or inspected by this method, which uses a low resistance millivoltmeter, calibrated leads, and steel probe rods with heat treated tips to facilitate obtaining low resistance contacts. One of the best known instruments for this purpose is the *Susquehanna Electrolysis Meter* designed by the late Dr. J. M. Pearson. It has a Weston Model M-1 volt-ammeter or equivalent built into a case containing a Wheatstone Bridge network for quick detection and correction for high probe rod contact resistances. The test set-up is shown in Fig. 3.

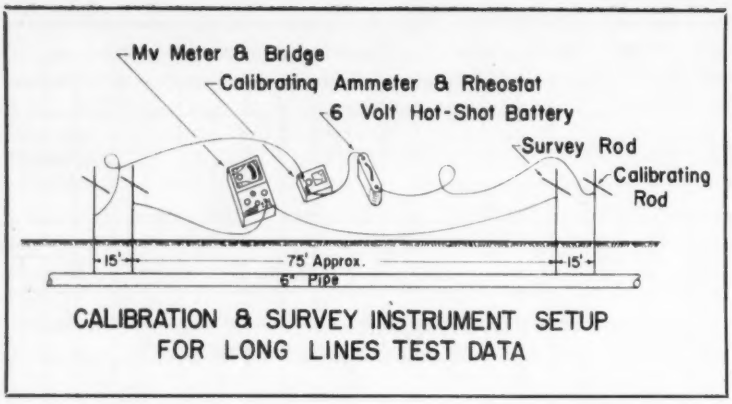
A long line current survey in 1950 of 432 miles of bare pipe required 85 working days, averaging 5 miles per day. Readings were taken about 700-ft apart on the average. Total anodic areas indicated were 835, or about two per mile. Correlation with actual leaks was not much better than 50%. Most pipeline corrosion is believed due to short concentration cells, and this method of inspection is not relevant. Fig. 2 shows 14 anodic points by the pipe to soil test, and 21 by the 2-electrode test, but only 6 anodic areas when the long line survey was made in this area.

It is highly recommended for study of stray currents and current losses in rivers or swamps where access is limited to each side.

McCullom Earth Current Meter

This excellent instrument, designed by Burton M. McCullom of the Bureau of Standards, will measure the value of earth resistivity and potential gradient from which can be calculated the current density being received from or discharged by an underground structure at a given point.

It includes a 1,000,000 ohm/volt sensitivity voltmeter, a panel type milliammeter, a commutator, batteries, and associated circuit for introducing pulsating d-c into the soil through a calibrated four terminal electrode. The electrode terminal arrangement is opposite to that of the Wenner arrange-



CALIBRATION & SURVEY INSTRUMENT SETUP FOR LONG LINES TEST DATA

Fig. 3.

Current Requirement Ratings for Coated Lines In High Resistivity Soils

GRADE OF COATING	Av. Microamps per Sq. Ft.
Excellent	0 - 5.0
Good	5.1 - 10.0
Average	10.1 - 20.0
Poor	21---100
Very Poor	101---240
Bare	241---1000

Fig. 4.

ment, the inner terminals carrying the current while the potential is read across the outer electrodes which are copper sulphate.

This test entails digging a post hole or bell hole to assure good contact of the four terminals, and careful levelling of the voltmeter, and hence is time consuming. Its best use is for special applications rather than on a multi-reading basis for long line survey.

The high resistance voltmeter can be used to good advantage in conjunction with standard copper sulphate electrodes to take pipe to soil potentials. The equipment uses several types of contactors, has a wide variety of uses, and is the only instrument designed to provide current density at a given point.[23]

Average current density over several lineal feet of pipe may be determined by taking a 4-terminal Wenner Method reading at right angles to the pipe and then using a high resistance voltmeter or equal, to take potential drop between the inner rods, noting polarity to show whether pipe is anodic or cathodic. Ratio of millivolt drop to average resistivity gives milliamperes for lineal feet tested.

Redox Potentials and pH

Microbiological corrosion of pipelines resulting from the activity of sulphate-reducing bacteria has been recognized for over 30 years. Most engineers today, for want of more knowledge on this interesting subject, assume that the normal cathodic protection criteria used to suppress galvanic corrosion, will also mitigate this type of corrosion if it exists along their partciular line.

Initially, a pH range of 7.0 plus or minus 0.8 was believed conducive to bacterial action. Evidence now indicates this bacterial growth will be supported within a pH range of 5.5 to 8.5.[24]

Early method of inspection consisted of adding hydrochloric acid to scrapings of the product of corrosion, resulting in evolution of hydrogen sulphide with its distinctive rotten egg odor. The inspection technique now has been refined to include use of a specially developed *Redox Probe* that measures oxidation-reduction potentials of the soil at existing or proposed pipe locations. Redox potentials E_h are corrected for pH and conversion of the calomel electrode used, to the value of hydrogen.

A scale of Redox Potentials has been devised that relates millivolts obtained between the calomel and platinum electrodes used, to degree of corrosion, and ranges from severe corrosion below 100-mv, to non-corrosive (bacterially that is) above 400-mv. The technique requires much time and care, and is essentially a research project, but will be watched with great interest as time goes on and more light is shed on current requirements for this unusual phenomena.[25]

Current — Potential Curves

Much fine work has been done in the laboratories in regard to the effects of dissolved oxygen, differential aeration, pH, polarization, and films . . . on corrosion rate. Attempts are being and have been made to reduce the mass of lab data to simple formulae that can be used as a practical guide in the inspection of corrosion and application of cathodic protection in the field.[26,27]

One such example is the *Current-Potential Curve* that, when corrected for IR drop, delineates the break in the curve that indicates that amount of current just necessary to effect protection.

The theory in this case is that, as test protection current is increased up to a certain point, the pipe-to-soil potential remains constant due to current absorption by the anodic areas that are small, in the normal case, in comparison to the cathodic areas.

When enough current is being supplied at the given point, for example along a pipeline, to just suppress the anodic local current, the cathode begins to act as a hydrogen electrode whose potential varies as the logarithm of the current input. Therefore, the break point at which potentials begin to move in a more negative direction gives the engineer a true measure of minimum current required for protection that automatically takes all factors into consideration. To date, however, application of this *Null Method technique* in the field has proven difficult and critical, and appears to give results comparable with the 0.3-v. lowering of potential.[28,29]

Application of Methods

The methods described are usually applied to bare or very poorly coated lines. Coated lines started to come into their own about 20 years ago, and coatings and application have made fast strides.

Coated lines are usually placed under solid protection without inspection as a matter of good insurance. Current requirements and cost of protection of well coated pipe runs about 4% of that for bare lines. Protection of coated systems is warranted because of the fact that currents picked up through holidays in cathodic areas, can discharge at anodic areas only through similar, usually small holidays at high current densities, and with consequent rapid pitting.

On bare pipe, discharge often occurs over relatively wide areas and anodic areas have been known to exist for years without failure due to uniform discharge from the pipe surface.

The condition of the coating and, therefore, a type of inspection and a measure of the need for protection is obtained when a current requirements test is performed on a new system. Fig. 4 gives a proposed "in place" current requirement rating for coatings on transmission lines in high resistivity soil areas.

In summarizing the subject of the value of Inspection Methods used in the field, we can say that in spite of

the difficulties in analyzing Nature's minute quantities involved, and the many shortcomings of present methods, almost any one or a combination of several, if carefully chosen and executed, will provide the engineer and management with the desired answers to the question of the need for cathodic protection. The more detailed and extensive the inspection, the more complete will be the corrosion picture. Value of the line will determine the degree of inspection.

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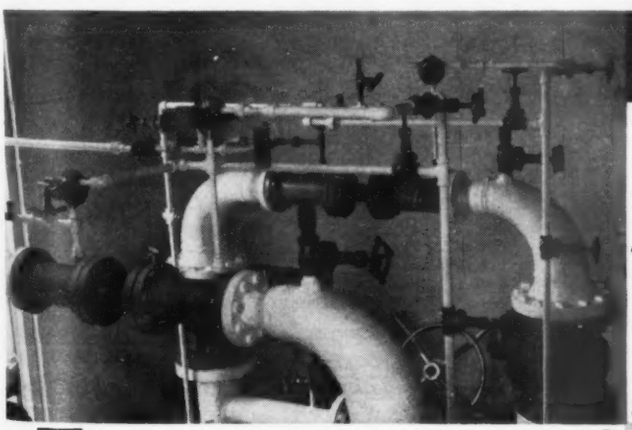

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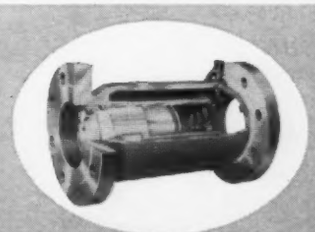

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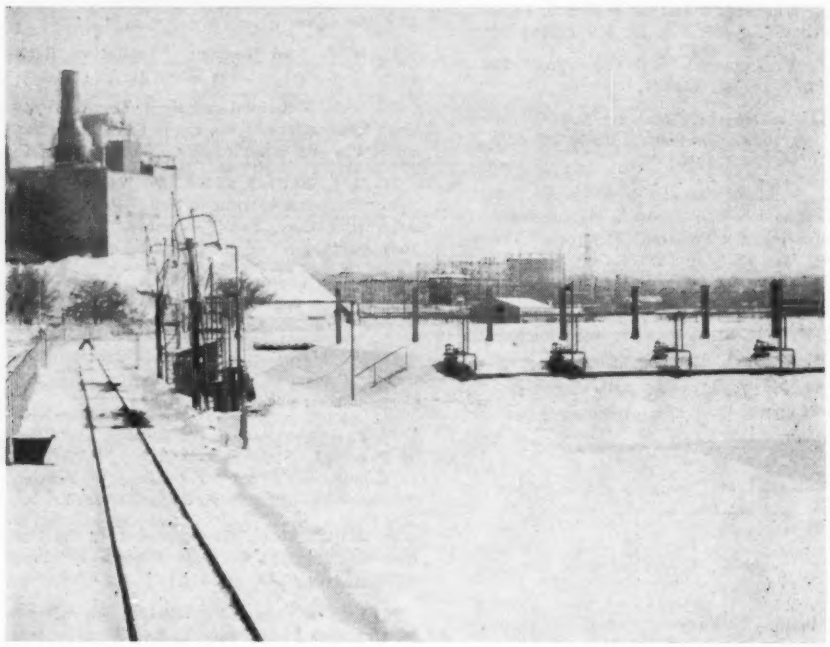
Twin unloading platforms for rail tank cars are at left. Mounded horizontal tanks are at right. Initially, eight tanks have been installed, with net capacity of 572,000-gal of propane. Provision has been made for four additional tanks.



A modern, 500,000 cfh propane-air plant in West Springfield, Massachusetts, completed in late 1960, is helping Springfield Gas Light Company meet heavy winter demands for gas service from its nearly 70,000 customers. The new auxiliary manufacturing plant will also provide a standby gas supply in the event of natural gas service interruption.

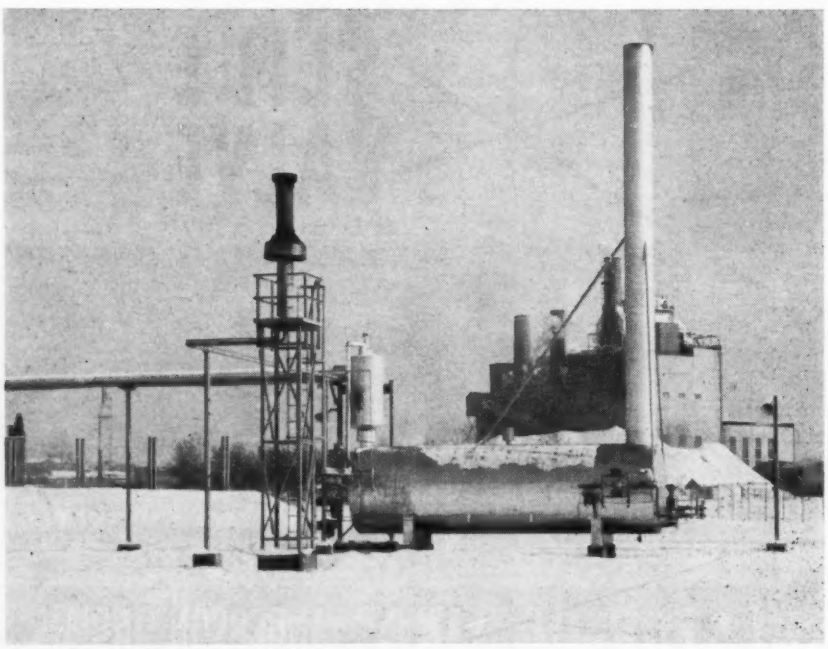
Designed to produce 1400 Btu per cu ft propane-air mixed gas and deliver it into the company's system at 95 psig, the new facility represents the latest in modern propane-air gas engineering. Highlight of the plant is the control center — a graphic panel in the control room. Included in the design are safety features — alarms and automatic shutdown controls — to cover every exigency.

Contract for the new plant was let in early 1960, with a planned completion date of November 1, 1960. A site in West Springfield was selected for the plant location . . . where the propane-air gas could be made and injected directly into the 20-in. main bringing natural gas from the Agawam Take Station to the utility's distribution system.

Adequate space is available at the site, and the plant was designed with this in mind, for easily doubling the capacity of the plant in the future. Ground conditions at the plant site are such that all buildings and heavy equipment require pile foundations.

Springfield Gas Light Installs New

V. C. Fimognari, *Assistant to the General Superintendent*
Springfield Gas Light Company, Springfield, Massachusetts



Vaporizer is a water-bath, indirect-fired type, uses prpane vapor as a fuel, is capable of vaporizing 8800 gal per hr of liquid propane to vapor at 110 psig and 90 F. To left of vaporizer is flare stack for waste gas.

Unloading Stations

Two tank car unloading stations are provided for simultaneously unloading two tank cars. The railroad siding can accomodate eight tank cars.

Each station is equipped with structural steel tower, stairway, platform and counterbalanced bridge to tank car manway. An unloading compressor with shelter, steel piping with swivel joints for tank car connections, a strainer, and sight flow check are installed at each station.

Storage Tanks

Piles, pile caps, and foundations were installed for twelve storage tanks of 80,300-gal gross capacity each. Initially, eight tanks were installed with total gross capacity of 642,400 gal., or approximately 572,000-gal. net of propane.

The tanks were installed with their horizontal centerlines at the approximate finished grade elevation then

backfilled with clean sand to 15-in. above top of shell. Finally, the top and sloping sides of the mound were finished with 3-in. of crushed stone.

To prevent floatation, the tanks are anchored to foundations. Hot applied bitumastic protective coating system was used on tank exterior surfaces. Cathodic protection is also provided.

All tank connections are welded or flanged. All valves, fittings, and piping are steel welded or flanged. Threaded joints were eliminated.

Vaporizer

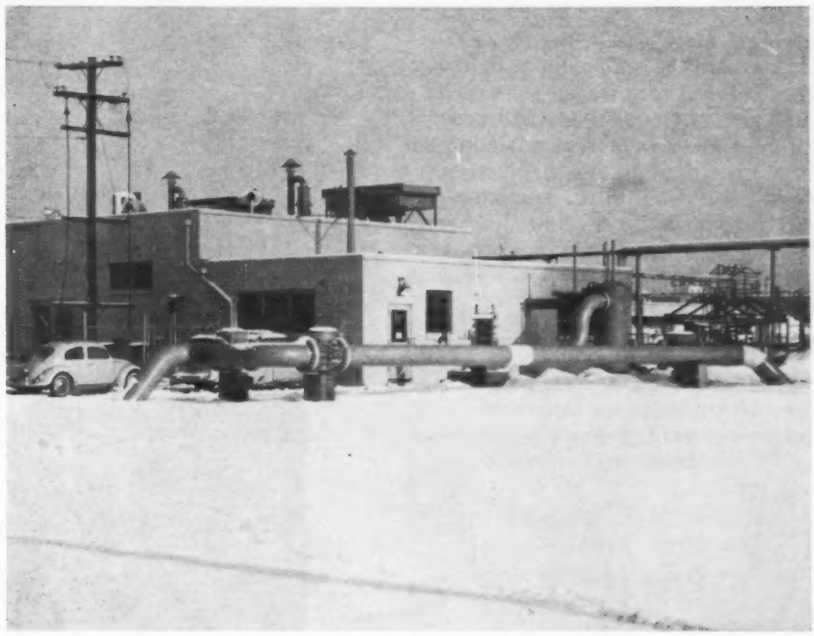
The vaporizer used at the plant is a water bath indirect-fired type using propane vapor as fuel. It is capable of vaporizing 8800-gal per hr of liquid propane to vapor at 110 psig and 90F.

Two pumps are installed to transfer propane liquid from the storage tanks to the vaporizer. The vaporizer is equipped with controls and safety devices for safe and proper operation.

Process Air Compressors

Two process air compressors of equal capacity are installed in the compressor room of the process building. Each compressor is a heavy duty, slow speed, gas engine drive, reciprocating type of 440-hp and capacity of 2088

Process building houses air compressors, gas mixing equipment, and control room. Each compressor has its own fan-cooled horizontal radiator, mounted on the building roof. In foreground is natural gas line.



Propane-Air Peak Shaving Plant

scfm air at 120 psig discharge. Propane vapor is used as fuel.

A separate closed cooling system is provided for each compressor and engine, with a fan-cooled horizontal radiator mounted on the building roof. The circulating pump is driven directly by the engine. Each system is complete with oil cooler, intercooler, aftercooler, temperature controls, thermometers, etc.

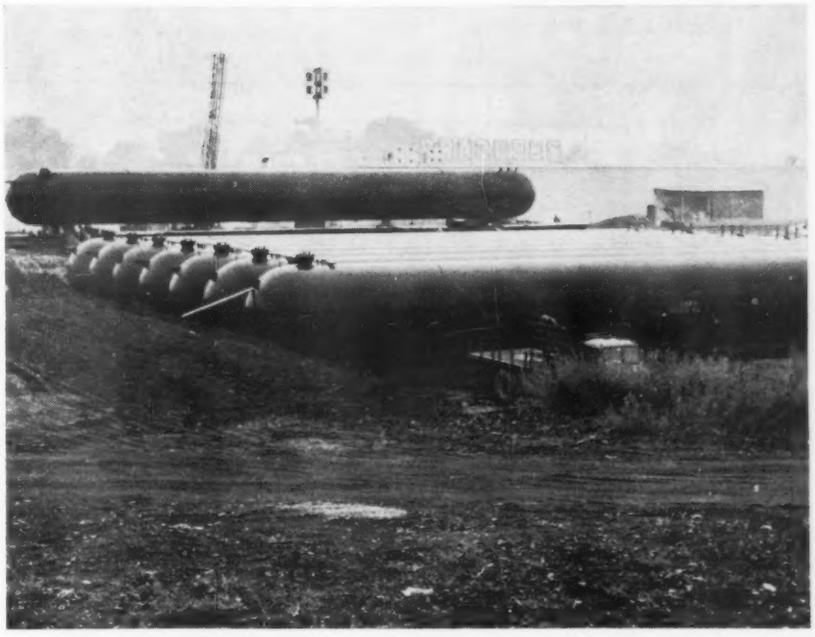
Each unit is equipped with air intake filter silencers for both air compressor and engine as well as exhaust silencer for engine. A common air receiver is located outside the building.

Engine speed and five-step unloading are automatically controlled from receiver pressure.

Gas Mixing Control

Control of gas mixing is done entirely from the *Graphic Instrument Panel* in the control room of the process building.

The control system is an assemblage of instruments, piping and valves, arranged to proportion the flow of propane vapor to the flow of natural gas according to a manually set ratio to maintain the desired percent of peak



80,000-gal tanks being installed. Foundations were provided for 12 tanks with eight tanks initially installed. Each tank has capacity of 80,300-gal gross, 72,000-gal net.

shaving. The system also proportions the flow of process air to the flow of propane vapor according to a manually set ratio to maintain the desired heating value (Btu cu ft) of the propane-air gas mixture.

To accomplish these functions there are two *Flow Recording Ratio Controllers* on the graphic panel, meter runs with d/p cell transmitters on natural gas, propane vapor, and process air lines, and flow control valves in propane vapor and process air lines.

Also included on the graphic panel are pressure gauges, flow totalizers, heating value indicators and recorders, specific gravity indicator recorder, and annunciator safety panel.

Safety System

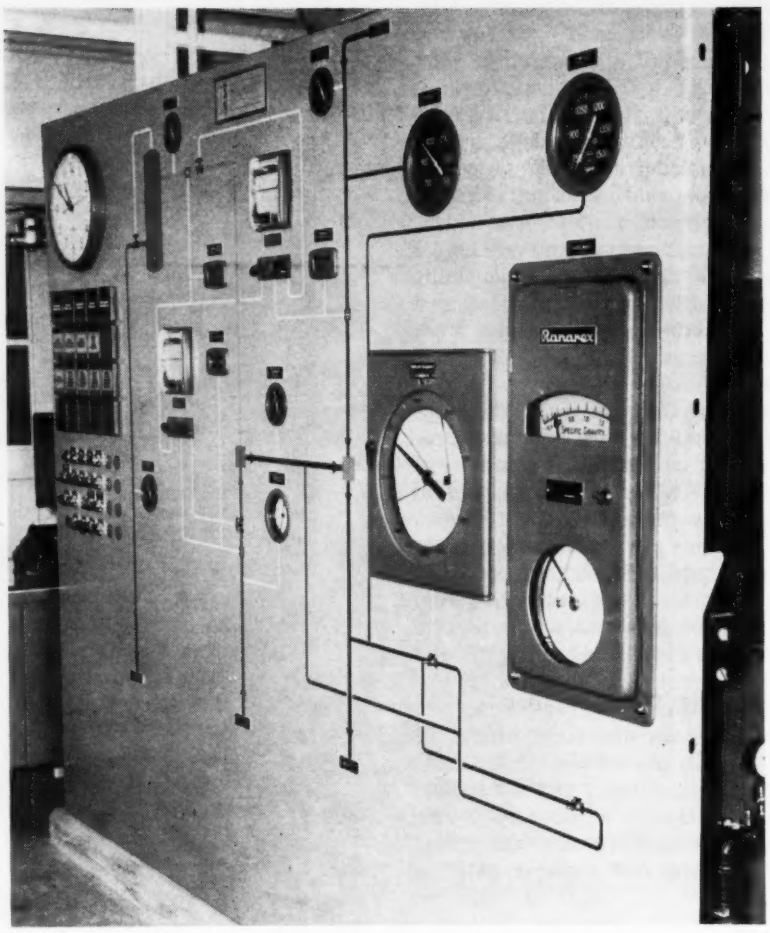
The safety system is an annunciator type consisting of an electro-mechanical arrangement to shut down the plant and give audible and visible alarm in case of:

Low Pressure—Propane Vapor
Low Flow—Propane Vapor
Low Pressure—Process Air
Low Flow—Process Air
Low Pressure—Instrument Air

The plant will also shut down in case of electric power failure.

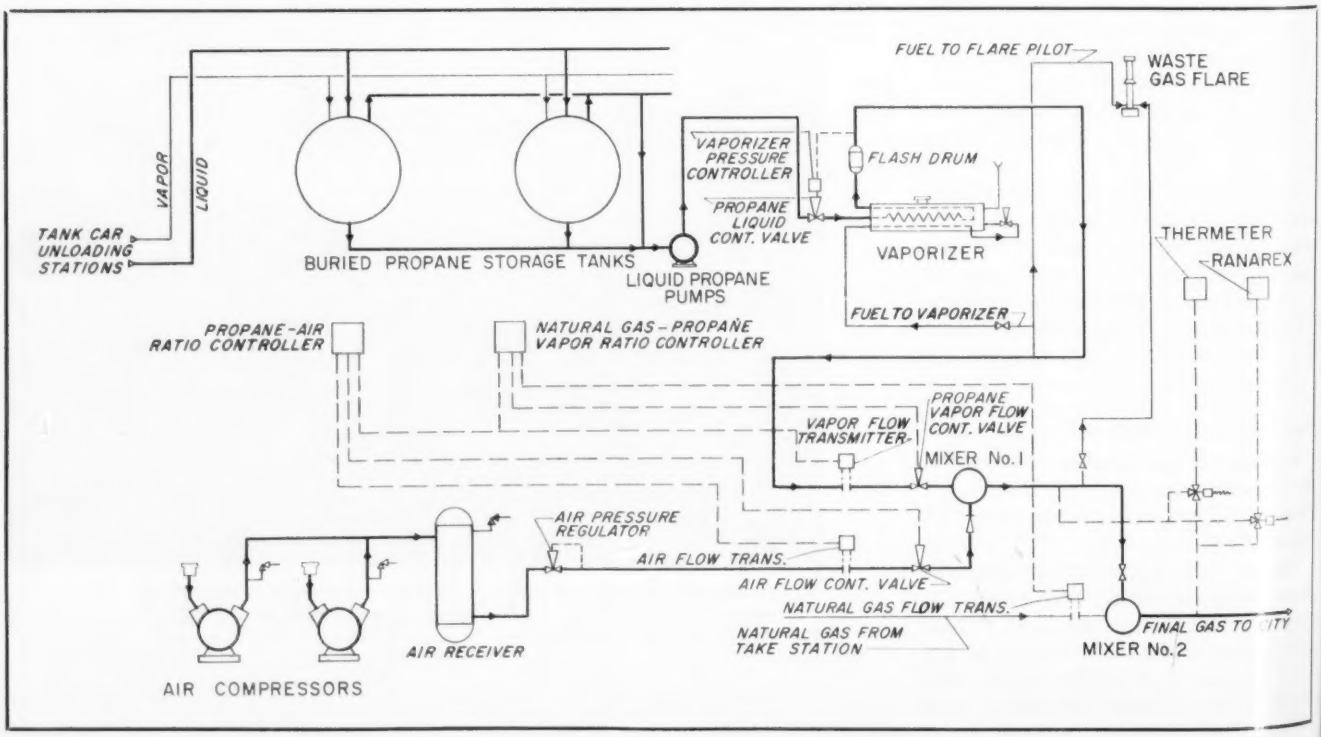
The safety system gives an audible and visible warning alarm, but does not shut down the plant, in case of:

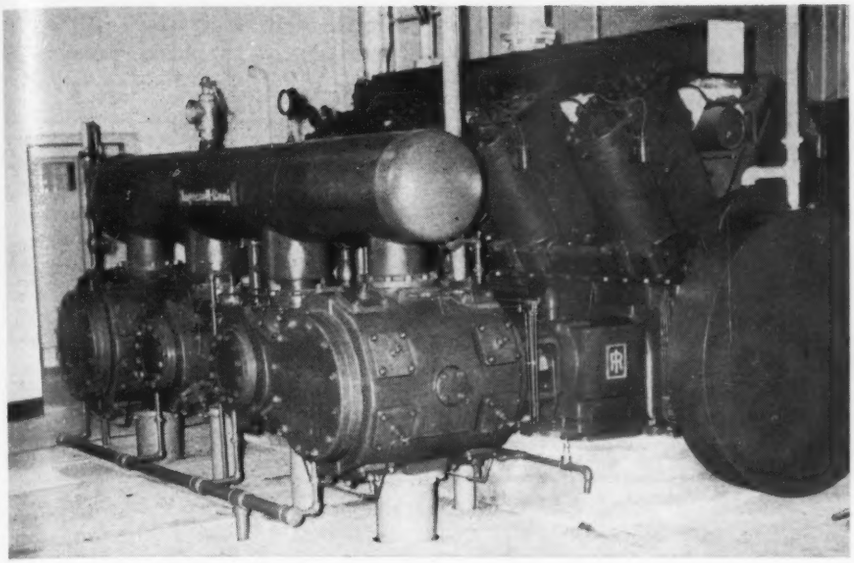
Lowering Pressure — Propane Vapor
Lowering Pressure—Process Air
Too High or Too Low Btu Value —Propane Air
Low Water Temperature or High Liquid Level at Vaporizer



Control center for plant's operation is this graphic panel in the control room. Annunciators (left, below clock) indicate safe or unsafe operation of all equipment. Btu value of natural gas, Btu value of propane-air gas, and specific gravity of the propane-air mixed gas or final send-out gas mixture are all indicated and recorded. Other data indicated includes propane liquid pressure, propane vapor pressure, process air pressure, valve positions, and natural gas pressure. Rate of flow of natural gas, propane vapor, and process air are all indicated, recorded, and totalized.

Simplified flow diagram of Springfield Gas Light Company's propane-air peak shaving plant at West Springfield, Massachusetts.





Gas engine driven compressors, 440-hp each with rated capacity of 2088 scfm at 120 psig, provide process air for the propane-air gas plant. Engines use propane vapor as fuel.

Low Oil Pressure—Compressor Engine No. 1
High Water Temperature—Compressor Engine No. 1
Low Oil Pressure—Compressor Engine No. 2
High Water Temperature—Compressor Engine No. 2

A green light is lighted when all safety devices are in safe positon and reset button is pushed.

Instrument Air System

The instrument air system consists of an instrument air compressor and an instrument air dryer, together with various filters, regulators and valves.

The *OFF-ON* selector switch for the instrument air compressor is on the graphic panel. With this switch in the *ON* position, the compressor will automatically start and stop to maintain air pressure in the receiver.

The instrument air compressor is a non-lubricated, water cooled compressor. A pressure regulator is installed in the air outlet line from the receiver to maintain a steady pressure of approximately 65 psig supply to the instrument air dryer and instrument air mains. All instrument air passes through the instrument air dryer where it is filtered and dried so as not to foul the instruments.

Emergency Stand-by Generator

An emergency stand-by generator has been provided to furnish sufficient electric power to operate the plant in case of power failure.

This is a gas engine generator set of 85-kva capacity. The engine is fuelled with propane vapor. This unit is arranged for manual starting and stopping and manual transfer power switch.

Operation

This plant was designed and constructed primarily for safety, dependability, flexibility and ease of operation.

Control center for the plant is the graphic panel in the control room. Safe or unsafe operation of all equipment is indicated on this panel as well as propane liquid pressure, propane vapor pressure, process air pressure, position of propane vapor flow control valve, position of process air flow control valve, propane-air mixed gas pressure and natural gas pressure.

Rate of flow of natural gas, propane vapor, and process air are all indicated, recorded and totalized. Btu value of natural gas is indicated and recorded. Btu value of propane-air mixed gas and/or final send-out gas mixture is indicated and recorded. Specific gravity of propane-air mixed gas and/or final send-out gas mixture is indicated and recorded.

Heating value of propane-air mixed gas is adjusted at the graphic panel to any desired point from 1000 to 1500 Btu per cu ft.

Percentage of peak shaving is adjusted at the graphic panel to any desired point within the capacity limitations of the plant. Or, if desired, a fixed rate of make can be set at the panel for the propane-air mixture.

Acknowledgments

Design and construction — Smith and Norrington Engineering Corporation; *storage tanks* — ACF Industries; *pumps* — Corken's Incorporated; *vaporizer* — Black, Sivalls & Bryson, Inc.; *air compressors* — Ingersoll-Rand Company; *pressure regulators*—Fisher Governor Company, and *graphic panel and controls*—The Foxboro Company.

* * *

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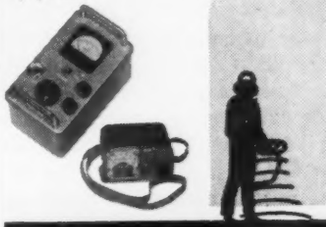

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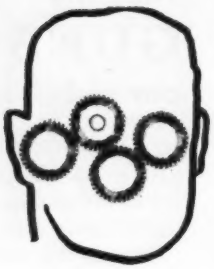
Using the Gears  Between the Ears

LAY THAT SLIDE RULE DOWN!

Part 3

FUN WITH TRIANGLES

Prof. Paul J. Grogan, *Chairman*
Department of Engineering, University Extension Division
University of Wisconsin, Madison, Wisconsin

Knowledge of the familiar 3-4-5 right-angle triangle dates back through untold centuries to the ancient civilization of the Egyptians and the Chinese. It served the purpose of helping man lay out squarely his plots and tracts of land, his villages and towns, his highways and canals, and his buildings and monuments.

Although these ancient men commonly employed the 3-4-5 principle for the construction of a right angle, it is believed they were satisfied with the results so obtained and considered not why they were so. The knowledge was simply handed down along with the other arts and crafts necessary for the survival of their civilization.

Pythagoras, a frequent visitor to Egypt in the Sixth Century B. C., picked up much of the learning of that country and was the first man history records as having stated the proof which has become a classic in Euclidian geometry.

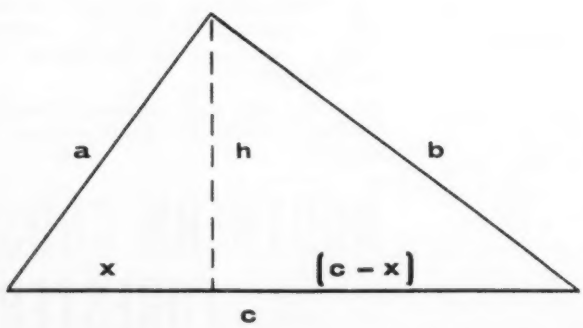
We recall a simple proof with the right-angle triangle, **abc,** appearing in Fig. 1. By similar triangles,

$$1)\ \frac{a}{x} = \frac{c}{a}, \text{ or } a^2 = cx$$

$$2)\ \frac{b}{c-x} = \frac{c}{b}, \text{ or } b^2 = c(c-x)$$

Adding 1) and 2)

$$3)\ a^2 + b^2 = cx + c(c-x) = c^2$$



Thus we have a general expression involving the three sides, **a, b,** and **c,** of a right-angle triangle. What other such triangles are there with integer sides? Mention of 6-8-10 and 9-12-15 are simply the same old familiar 3-4-5 triangle under a slight disguise.

Quite by accident, we may have chanced upon 5-12-13 and/or 7-24-25 as other integer combinations which form right-angle triangles, and we should begin to suspect there are a great many more that can be formed.

From a table of squares appearing in Part 1, we recall:

$$26^2 = 24^2 + 100 = 24^2 + 10^2; \text{ or}$$

10-24-26 is a combination

$$29^2 = 21^2 + 400 = 21^2 + 20^2; \text{ or}$$

20-21-29 is a combination

Continuing with the aid of the identity we found useful in this earlier part,

$$34^2 = 16^2 + 900 = 16^2 + 30^2; \text{ or}$$

16-30-34 is a combination

$$41^2 = 9^2 + 1600 = 9^2 + 40^2; \text{ or}$$

9-40-41 is a combination

At the expense of some repetition, we may soon establish a particular right-angle combination to fit every small integer larger than two.

Odd Numbers		Even Numbers	
3.	3- 4- 5	**4.**	4- 3- 5
5.	5-12-13	**6.**	6- 8-10
7.	7-24-25	**8.**	8-15-17
9.	9-40-41	**10.**	10-24-26

These, in turn, may eventually be reduced to the form of identities, where **a, b,** and **c** are the three sides of the triangle and **n** is any integer.

Odd Numbers	Even Numbers
$a = (2n-1)$	$a = 2n$
$b = \frac{(2n-1)^2 - 1}{2}$	$b = n^2 - 1$
$c = \frac{(2n-1)^2 + 1}{2}$	$c = n^2 + 1$

The reader may verify the identities by adding the squares of a and **b** to obtain the square of **c.** From these identities it also may be shown that 1-0-1 and 2-0-2 are limiting cases of the right-angle triangle that apply to the two integers left out heretofore. Thus we see there are simply as many of these combinations as there are integers. In other words, the number is truly infinite.

Continuing the tabular information of right-angle triangles for each odd and even integer started above, we are now able to obtain new combinations in abundance.

11.	11- 60- 61	**12.**	12-35- 37
13.	13- 84- 85	**14.**	14-43- 45
15.	15-112-113	**16.**	16-63- 65
17.	17-144-145	**18.**	18-80- 82
19.	19-180-181	**20.**	20-99-101

Possibly we should stop searching for any more of these special triangles now that it has been established there is one that fits every positive integer. Yet we sometimes happen across an example that cannot be classified according to either of the two groups we have established heretofore. The integer 20 is a part of no fewer than five different combinations, 12-16-20, 15-20-25, 20-21-29, 20-48-52, and 20-99-101. Two of the examples may not be reduced to simpler form, and one of the examples lies outside of the defining identities. There must be more of these oddities, but a new defining relation is required.

There happens to be just such a relation that arises in the most round-about way. Recalling the double-angle formula from trigonometry,

$$\tan 2\theta = \frac{2 \tan \theta}{1 - \tan^2 \theta}$$

Now, if $\tan \theta = a/b$, an integer fraction, then

$$\tan 2\theta = \frac{2a/b}{1 - a^2/b^2} = \frac{2a/b}{1 - a^2/b^2} \cdot \frac{b^2}{b^2}$$

$$= \frac{2ab}{b^2 - a^2}$$

Thus, $\tan 2\theta$ is still an integer fraction, and $2ab$ along with $(b^2 - a^2)$ may be used to form the two legs of a right-angle triangle. Further, obtaining the square root of the sum of their squares reveals the third side, or the hypotenuse, to be $(b^2 + a^2)$. Therefore the three sides of the triangle so formed are all integer values. Given **any** integer fraction, a/b, less than unity, a right-angle triangle follows.

The following form, with a few examples, is suggested for the mass production of these special triangles that now seem to permeate the atmosphere. It is suggested that the investigation proceed systematically with integer fractions such as ½, ⅓, ¼, ⅕, etc., until it becomes evident just what further types will appear from that series. Then begin 2/3, 2/4, 2/5, etc., until a new series unfolds. Each numerator, when used in combination with the successive integers as a denominator, will produce a series of triangles which may be found by inspection after the first four or five examples.

TABLE 3. Right-angle Triangles from Double-Angle Formula.

a	b	a^2	b^2	2ab	b^2-a^2	b^2+a^2	Triangle
1	2	1	4	4	3	5	3- 4- 5
2	7	4	49	28	45	53	28-48-53
3	8	9	64	48	55	73	48-55-73

The preceding discussion is largely purely theoretical and may appear to have little practical application. Yet, it has been passed along to spur an interest in these phenomena and has been presented with the hope the reader will come into closer working contact with the readily available network of facts and data which are number theory.

Wear is what makes the old shoe fit comfortably, and it takes wear to make the information contained in this and the preceding parts useful in our everyday practice.

There are problems everywhere throughout engineering endeavor that involve the addition of vector quantities in a two-dimensional system. Every one of these problems can be reduced to the mere solution of a right-angle triangle.

Given the **X** and **Y** components of two or more vector quantities, the situation often arises that the sum of the vector components along one of the axes will predominate. An example is an alternating-current electrical circuit analysis with some reactance, but largely resistance prevailing.

Another problem is a turbine stage velocity diagram where either the **X** or the **Y** components of the steam velocity may be small, depending upon whether inlet or exit velocities are in mind. There are countless tractive and friction problems where a small grade or incline is involved.

As an example, assume a resistance, $R_x = 110$ ohms, and the net reactance, $R_y = 15$ ohms. Applying methods which have been presented heretofore, we may reason that $R_y^2 = 225$ units. We also know that the interval between 110^2 and 111^2 comprises some 221 units. We may therefore simply state that if,

$$Z^2 = R_x^2 + R_y^2 \text{ ohms,}$$

$$Z = 110 + \frac{225}{221}$$

$$= 111 + \frac{4}{222} = 111 + 1/55.5$$

Now, we should recall that $1/18 = 0.0555\ldots$. Turn about being fair play, $1/55.5 = 0.018$. We may now state Z to a greater degree of precision than any of our measurements probably allow:

$$Z = 111.018 \text{ ohms.}$$

Or, in a turbine problem, given an equation

$$V_t^2 = V_x^2 + V_y^2 \text{ ft per sec.}$$

Data are supplied, $V_x = 50$ ft per sec, and $V_y = 410$ ft per sec.

We quickly ascertain $V_x^2 = 2500$ units. Applying these units to the task of increasing the square of V_y to include the square of the next and succeeding integers beyond 410, we immediately see that hardly more than three additional integers can be included. It takes 821 units to get from 410^2 to 411^2, an additional 823 units to get from 411^2 to 412^2, and lastly 825 units are required to include the difference between 412^2 and 413^2. Including three significant figures, the solution of $V_4 = 413$ ft per sec is complete.

Assuming a new circumstance in which the hypotenuse is known, along with a proportionately small side, determine the other leg. For example, given:

$$F^2 = F_x^2 + F_y^2,$$

where

$$F = 2000 \text{ lb,}$$
$$F_y = 600 \text{ lb;}$$

find F_x.

Nearly 4000 units in terms of F_y^2 are required to give an F_x a single pound less than F, itself. As it happens, $F_y^2 = 360{,}000$ units, or enough for 90 such intervals. Now we may state cautiously that $F_x = 1910$ lb.

We nevertheless realize that we have applied an approximation method, which is only nearly exact for the **first** interval, through **89** additional increments.

Yet, if we perform the actual solution by longhand methods, the four-place answer is $F_x = 1908$ lb. The accuracy of the method is 99.9% whereas the angle involved is the arcsin 0.3000, or approximately 17.5°. We mention this because the accuracy depends upon the magnitude of the acute angle involved, and not upon the length of the sides.

You may verify that the method is approximately 99% correct where the angle is 30°. Insofar as either one acute angle or the other in a right triangle has a good chance of being smaller than 30°, the method may be employed over a wide range of application.

In assuming above that $F_x = F - F_y^2/2F$, an error of a single unit was made in the first application of the approximation, three units error appeared in the second approximation, then five units error, seven, nine, etc., units in each succeeding approximation until 179 units error was introduced in the 90th instance.

In all the accumulative error is:

$$\text{Units error} = 1 + 3 + 5 + \ldots + (2n-1), \text{ where } n = 90.$$

From our earlier discussions we should also recognize the sum of our accumulated error, the series above, as also being the square of 90. Therefore, the accumulated error after 90 intervals totals 8100 units. These, in turn, suggest that two additional intervals may be included, or F = 1908 lb. This solution now agrees with the calculated answer referred to above.

As a matter of fact, we may tabulate the problem as below and eventually arrive at any desired degree of accuracy.

$$F_x = 1910 - \frac{8100}{3819}$$

$$= 1909 - \frac{4281}{3817}$$

$$= 1908 - \frac{464}{3815}$$

$$= 1908 - 0.12$$

$$= 1907.88.$$

Although we started with 3-4-5 as a right triangle, we now also recognized 600-1907.88-2000 as being another. ∎

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Distribution Developments

NEWS ABOUT CURRENT AND PLANNED CONSTRUCTION

Lone Star Gas Company, Dallas, Texas, has budgeted a record amount for 1961 to expand and strengthen natural gas service in and around the 462 communities served by the utility in Texas and Southern Oklahoma. A total budget of $33,600,000 is slated for investment during the year. Company's distribution operations will spend the largest share — $12,900,000 — while $9,800,000 will be spent by the company's transmission division and the wholly-owned subsidiary, Lone Star Producing Company, will spend $10,900,000.

Expenditures for new distributions mains, services, meters, and regulators; fortification of existing facilities; improvements and additions and new equipment include: General division of distribution — total of $6,800,000 including $4,376,000 for new construction; Dallas division of distribution — total of $3,184,000 including $2,620,000 for new construction; and Fort Worth division of distribution — total of $2,990,000 including $2,179,000 for new construction.

Plateau Natural Gas Company, Denver, Colorado, plans to construct distribution systems in the towns of Monument and Palmer Lake at an estimated cost of $165,000. Supplier will be Colorado Interstate Gas Co.

Mississippi Gas Corporation, Natchez, Mississippi, plans to install distribution systems in Bogue Chitto, and Norfield, in Lincoln County, Mississippi, at an estimated cost of $55,000. A 40 ft 2-in. supply line to be constructed by United Gas Pipe Line Co. is pending FPC approval. Cost is estimated at $5,813 for short line, sales meter station, and other related facilities.

United Gas Improvement Company, Philadelphia, Pennsylvania, has set a $6,569,000 construction budget for 1961 for expansion and improvement of its gas facilities. Approximately $5,800,000 of this total will be spent in the company's 4 gas divisions—Reading, Lancaster, Lehigh, and Harrisburg. *(Expenditures to be made by Philadelphia Gas Works, Div. of U.G.I., are not included in the figures.)* Balance of the total budget will be spent in central operations in Philadelphia and Reading. At the latter, U.G.I. has operated a central meter repair shop for all divisions for a number of years and just recently established an accounting center to perform the large volume operations of customer billing and accounting for the entire system.

Public Service Company of Colorado, Denver, Colorado, estimates it will spend $9,807,000 for expansion and maintenance of its gas distribution systems. Another $3,129,000 will be utilized for construction of general plant facilities.

Yearly Public Service has been adding 12,000 gas customers. Expenditures for the new Public Service Company office building in downtown Denver are not included in the 1961 $9 million budget as the building is being constructed by a subsidiary company.

Company plans to build a $94,600 distribution system to serve town of Niwot, Colorado. Supplier will be Colorado Wyoming Gas Co., subsidiary company, who has FPC okay to construct a 4-in. lateral tap line and town meter station.

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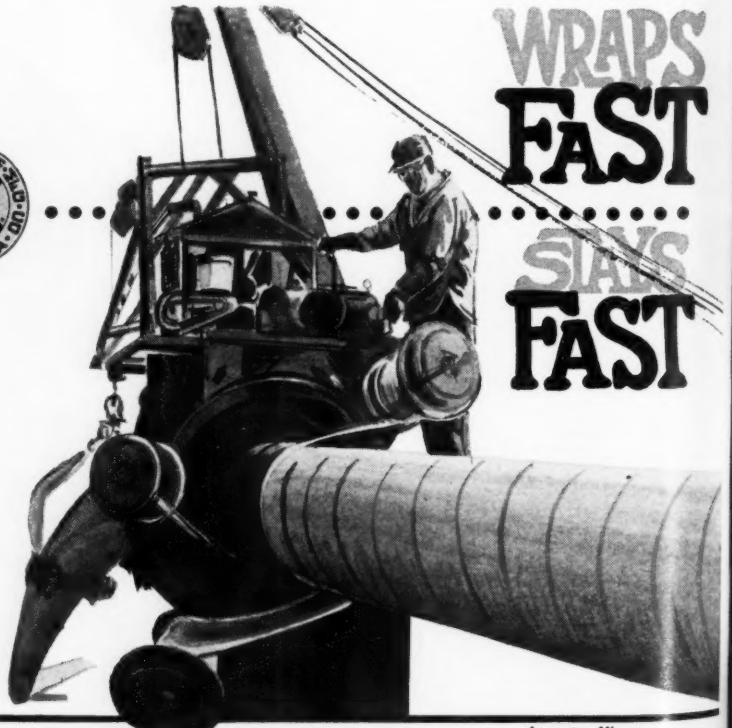

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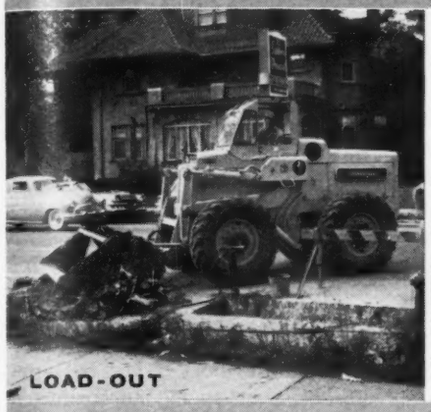
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Distribution Developments

East Ohio Gas Company, Cleveland, Ohio, plans to spend approximately $17,245,000 for new distribution construction in 1961. Of this total distribution budget, approximately $304,000 will be spent for new lines in the Cleveland area; $400,000 for relocation of distribution mains in the path of freeway construction in the Greater Cleveland Area. $10,900,000 will be spent for normal additions to the East Ohio distribution system; $3,100,000 for replacement projects in the distribution system. Approximately $1,900,000 has been tabbed for general system improvements. Company also plans to install a $641,000 service center in Wickliffe.

United Fuel Gas Company, Charleston, West Virginia, has installed 40 ft of 4-in. line from a tap on its 8-in. high pressure line near Neal, West Virginia, to measuring and regulating facilities to serve Novamont Corp. in Neal. Estimated cost of construction was $8650. Company crews completed project January 13.

Southern Union Gas Company, Dallas, Texas, has signed a contract to deliver approximately 10,000,000 cu ft of gas daily to the new $35 million paper mill now being built by Southwest Forest Industries, Inc. 15 miles west of Snowflake, Arizona. Approximately $1,500,000 will be invested jointly by Southern Union and El Paso Natural Gas in a 60-mile 8-in. line, metering stations, and related facilities before gas is turned on at plant next October. New line will tap El Paso Natural's San Juan main line near Holbrook.

Northern Illinois Gas Company, Aurora, Illinois, has boosted its 1961 construction budget to $43,000,000 and now plans to spend a total of $215,000,000 in the next 5 years. During 1960, NI-Gas spent approximately $53,000,000 with $10,000,000 going for the construction of a supply line from the utility's underground storage reservoir near Troy Grove, Illinois, to its distribution network.

Company recently acquired the Watseka, Illinois, municipal gas system, and plans to provide natural gas service to the community (south of Kankakee) this year, and to Crescent City, which granted the company a franchise in November.

Delaware Power & Light Company, Wilmington, Delaware, plans to construct a million cu ft per hour propane-air gas plant at an estimated cost of $750,000. The plant will be tied in with the recently announced mined underground LPG storage cavern of Sun Oil Company at Marcus Hook, Pennsylvania, and will be connected to Delaware's gas supply system at Claymont, Delaware.

United Gas Corporation, Shreveport, Louisiana, has acquired existing distribution facilities in the town of Van, Van Zandt County, Texas. Its affiliate, United Gas Pipe Line Co. has temporary authority from the FPC to build a 65-ft 4-in. supply line, sales meter station, and other facilities to serve Van. Cost is estimated at $7058.

STRAIGHT LINE PAN MOVEMENT

There's no chance for a diaphragm pan to start traveling in an arc when you install this improved Lancaster Carrier Wire Assembly.

SIDE CARRIER BRACKET **height can be quickly adjusted for most accurate positioning. No wire bending.**

OVAL SLOT CENTER BRACKET **permits diaphragm pan to travel straight through. No chance for wear.**

Oval slot center brackets available separately can be adapted to any carrier wire. Porous bronze and graphite bushings used throughout. Order now for easier installation and increased meter accuracy.

A meter is only as accurate as its parts . . . and Lancaster quality parts are guaranteed to outperform the original parts.

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Experienced Natural Gas Distribution System Operator

Gas manager position available to qualified person in prosperous Iowa community. Six to eight years experience required in gas distribution system operation, maintenance, appliance adjustment and inspection. Position will require control of gas loads, meeting public as cities gas representative and manager, and other management and inspection duties.

Address replies and resume of qualifications to CITY CLERK, Manilla, Iowa

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BERRY EQUIPMENT CO., Memphis 3

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BOLSTAD SALES & SERVICE, San Pedro
GENERAL BEARINGS CO., Fresno 6
GILMORE SUPPLY CO., San Francisco 3
HOFFMEYER BELTING & SUPPLY, Oakland 6
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Newark 2

NEW MEXICO
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NEW YORK
NIELSEN HYDRAULIC EQUIP., Pelham Manor
CLARK-WITBECK, Schenectady 1
ENGINE EQUIP. SERVICE, New York 61
POWER DRIVES, INC., Buffalo 20

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OREGON
GOODYEAR RUBBER & SUPPLY, Portland 9

PENNSYLVANIA
CYPHER COMPANY, Pittsburgh 6
RONCO CORPORATION, Blue Bell (sub. of Phil.)

TENNESSEE
BERRY EQUIPMENT CO., Memphis 3

TEXAS
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Repair pipe leaks quickly, safely

PATCHMASTER

heavy-duty pipe repair clamp

The Marman Heavy-duty PATCHMASTER Pipe Repair Clamp is designed to stop pipe leaks in oil, gas, water and steam lines quickly, easily, safely and permanently. Corrosion resistant stainless steel band conforms to pipe contours, seals leak with a synthetic rubber pad. Special lug applies high torque without biting into pipe. Full range of sizes from ½" through 24" in standard pipe sizes, 2" through 8" in O.D. pipe sizes, in four different widths. Keep Marman PATCHMASTER on hand for emergency repairs.

other MARMAN products

FLEXMASTER PIPE JOINT

Joins pipe without threading, cutting or flanging. Full range of sizes from ⅜" through 4" in lengths up to 36". Also available in tees, crosses, 90° elbows and 45° elbows, for all O.D. pipe sizes. Allows up to 4° angular misalignment without leakage. FLEXMASTER allows for 150 lbs. service with a 4:1 safety factor. Design permits easy removal and installation. FLEXMASTER Pipe Joints can be reused again and again.

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Marman FLAGMASTERS let you identify pipe lines or post permanent instructions or warnings. Flag and band are of non-corrosive stainless steel. Flag is 2"x4" for ample message area. Is easily and quickly installed on any pipe, tube pole or rod. Four diameter sizes from 2⅝" to 16⅛".

MARMAN HOSE CLAMPS

Marman Hose Clamps are for general industrial applications. Of stainless steel, in slotted screw or thumbscrew style, they are available in diameters from ⅜" through 7", have wide diameter adjustment.

Patent Applied For

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Marman Products are covered by U.S. and foreign patents and other patents pending
PATCHMASTER, FLEXMASTER, FLAGMASTER are Aeroquip Trademarks

Distribution Developments

Laclede Gas Company, St. Louis, Missouri, plans to spend approximately $13,200,000—$800,000 more than last year—on new construction. *(Between now and the end of 1965, Laclede expects to spend more than $60,000,000 for construction of new and larger distribution facilities.)* Of the $13,000,000 allocated for 1961, approximately $2,200,000 will be spent for a 10-mile 20-in. belt line *(now under construction)* to connect Laclede's system with Mississippi River Fuel's new transmission line at a delivery point near Chain of Rocks Bridge. At Bellefontaine Road, the new belt line will split into two arms, one heading west about 9 miles to connect with underground storage facilities. The second branch will be constructed to the south tying the new line in with the north end of Laclede's present distribution system.

San Antonio City Public Service Board, San Antonio, Texas, has contracted with Alamo Gas Supply Co. for a 20-year supply of natural gas. SACPS operates a municipally-owned gas distribution system in the south central Texas city. Alamo Gas Supply has awarded a contract to O. R. Burden Construction Corp. to install a 291-mile supply line of 14- through 24-in. pipe in southwest Texas to supply gas to San Antonio. Construction will get underway this spring.

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DOMESTIC SERVICE REGULATOR

Developed specifically for house service installations, the economical Series 1200 four-inch diaphragm class regulators provide many *exclusive* quality features with field-proven, dependable performance. Series 1200 Reliance regulators provide the most advanced design for those companies whose systems lend themselves to use of small regulators for compact meter settings.

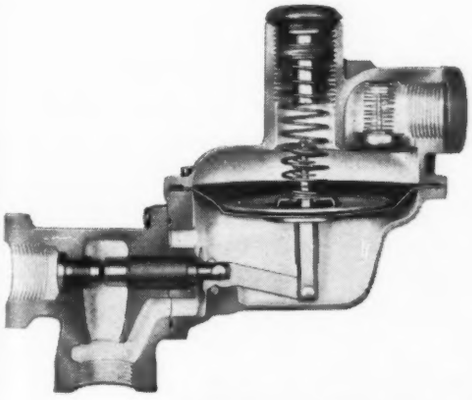
Capacity of the 1200 Series is 270 cfh at 2 psi inlet, $\frac{5}{16}$-inch orifice and 1-inch w.c. pressure drop, with correspondingly higher capacities for other inlet pressures and orifices. Suitable for inlet pressures to 125 psi and outlet pressures from 5- to 15-inches w.c. Manufactured to conform to A.S.A. Code requirements.

Two models are available . . . standard Model 1203 and *full capacity internal relief* Model 1213B. Both models are also provided as Series 1300 regulators with *detachable* meter bar for 6- or 11¼-inch connection centers.

See Bulletin 105 for complete details and specifications.

CHECK THESE EXCLUSIVE FEATURES!

- RUGGED CAST IRON PIPE SECTION provides maximum strength — prevents thread galling.
- POSITIVE LOCKUP — gives over 20% greater available lockup power than any comparable regulator of its class — provides greater safety factor in event of foreign matter on valve seat.
- REMOVABLE DIAPHRAGM SECTION for ease of servicing without disturbing piping connections — valve seat disc easily replaced.
- TWO-PIECE CONSTRUCTION permits choice of four valve head positions.
- ADJUSTABLE RELIEF VALVE for accurate setting of any desired relief pressure.
- DETACHABLE METER BAR models available for both 6- and 11¼-inch connection centers.



CHECK THESE QUALITY FEATURES!

- Compact design reduces meter set assembly costs — elbow-type cast iron head simplifies piping connections.
- Relief valve stop assures relief valve operation under the most severe conditions.
- Extra-large ¾-inch weatherproof screened vent provided in four basic positions.
- Die-cast aluminum alloy body and top for ease in handling, shipping and setting.
- Brass orifice easily changed through inlet connection.
- 125 psi maximum inlet pressure. Springs available for outlet pressures from 5- to 15-inches w.c. Body sizes ¾- and 1-inch. Orifice sizes ⅛-, 3/16-, ¼-, and 5/16-inches.

AMERICAN METER CO. EST. 1836

AMERICAN® METER COMPANY

GEM

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SUPPLIERS TO THE GAS INDUSTRY for Ironcase, Tinned Steelcase, Aluminumcase and Welded Steelcase Meters • American-Westcott Orifice Meters • Instruments • Reliance Regulators • Apparatus • Valves

Accurate Flow Volumes at All Times

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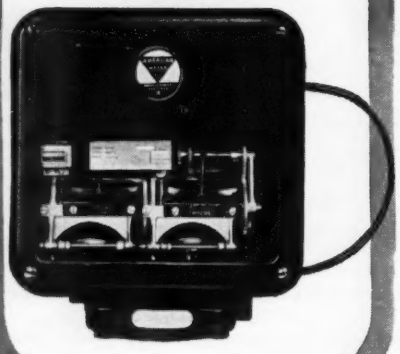

American Base Volume Indexes register the measured gas quantity at standard conditions of base pressure and base temperature on a direct reading counter. No computations... accurate gas volumes are shown continuously and immediately.

A second counter also indicates the gas volume at line conditions. Simple operating principle... integration is continuous with all functions performed mechanically through special gearing.

Write for Bulletin 200 for complete information.

AMERICAN METER CO. EST. 1836 MEASUREMENT ENGINEERS

AMERICAN METER COMPANY

INCORPORATED ESTABLISHED 1836

General Offices: Philadelphia 16, Pa.
Sales Offices in Principal Cities

Distribution Developments

Iowa Electric Light and Power Company, Cedar Rapids, Iowa, plans to spend approximately $954,932 for new gas distribution construction in 1961. Twelve new communities are in line for company's expansion of natural gas service with $427,548 budgeted for that purpose. They are: Corwith, Goodell, Hubbard, Kanawha, Winthrop, Gilbert, Holland, Roland, Meservey, Owasa, Alexander and Chariton.

Southern California Gas Company, Los Angeles, California, has set a $27,745,000 1961 construction budget. Biggest single item is $10,300,000 for addition of mains, meters, and services to supply new customers. This allocation is based on an estimate of 58,000 additional new business meter outlets during the year. Quite a number of these meters, however, will also be removed for freeway construction, etc. resulting in a net gain of considerably less than 58,000. Other major expenditures include $7,200,000 provided for distribution and transmission system betterments and replacement. $9,000,000 has been set for SoCal's portion of the Ivanpah-to-Newberry supply line in the proposed Rock Springs Project. Southern Counties Gas Co., SoCal's sister company, plans $3,750,000 for its portion of this line. Other expenditures planned for 1961 include $400,000 for furniture, equipment, etc.; $360,000 for buildings, alterations and improvements, and $323,000 for improvements of underground storage facilities.

POSITION AVAILABLE

Experienced Natural Gas Distribution System Operator

Gas manager position available to qualified person in prosperous Iowa community. Six to eight years experience required in gas distribution system operation, maintenance, appliance adjustment and inspection. Position will require control of gas loads, meeting public as cities gas representative and manager, and other management and inspection duties.

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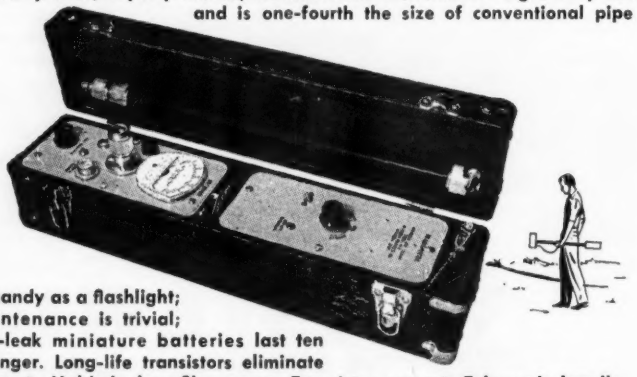
The MINIATURIZED-PRECISION WILKINSON Line Locator Model W-3

This radically new, super-powered, transistorized instrument weighs only four pounds and is one-fourth the size of conventional pipe locators.



It is as handy as a flashlight; the maintenance is trivial; the non-leak miniature batteries last ten times longer. Long-life transistors eliminate replacement. Molded glass fibre cases. Transistor ear set. Telescopic handle. Etches circuitry. Contained in carrying case.

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Gas utilities may have, free of charge, GEM newspaper mats of attractive ads designed to encourage the use of gas-fueled appliances. Available at cost are GEM direct mail pieces which may be sent to your customers. Write to GEM.

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Product Parade

A New Decade for New Products . . . In the next 10 years, the gas industry, it is estimated, will spend more on research and development than in its previous 144 years of existence. *What will these advances in technology mean to you?* To keep you in touch, we review each month the more outstanding new developments as they appear. You can get additional information just by circling . . . *on the reader reply card in this issue* . . . the numbers appearing at the end of each item.

New gas absorption cooler . . . developed by Stratham Instruments, Inc. . . . operates on the principle of producing cold from a gas flame by application of the two-effect generator principle to a lithium bromide-water absorption cycle. Unit is specifically developed for use as economical air conditioning unit for large structures such as office buildings, hotels, plants, hospitals, etc. **1**

Packaged air compressors for industrial applications are described in Bulletin 203 just issued by Clark Bros. Co., Div. of Dresser Industries, Inc. Line includes 4 models rated at 25, 50, 75 and 100-hp respectively. Complete list of dimensions, weights, and specifications for units are included in the brochure. **2**

Storage of liquefied petroleum gases at extremely low temperatures is the subject of a new 16-page brochure, *Cryogenic Storage Vessels*, published by Chicago Bridge & Iron Co. Design of double-wall storage vessels, insulation systems, materials of construction, and accessories are described. **3**

Fisher Governor Co. has combined its pneumatically operated piston actuator with a rack and pinion to convert the linear motion of the piston rod to rotary motion. This actuator positions a rheostat in response to a pneumatic signal; produces 185 inch-pounds of torque with 40 psig air supply. **4**

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in your territory. From your desk you can earn a substantial addition to your income. Only written contracts with your clients! Write for particulars and further details to VKK-Office, Vienna 66, P. O. B. 128, Austria.

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Loading SPI c/w pipe for shipment.

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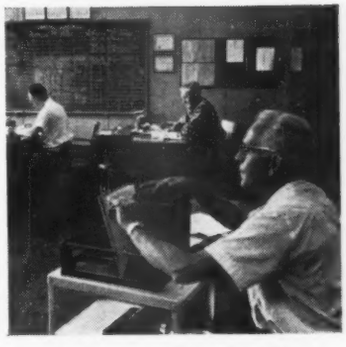
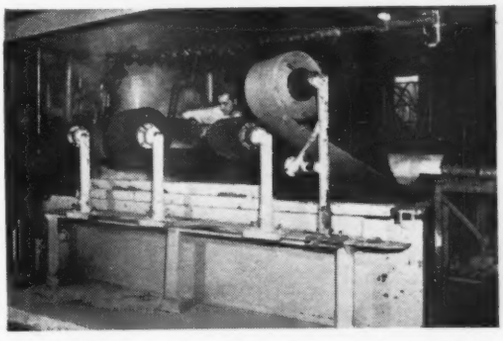
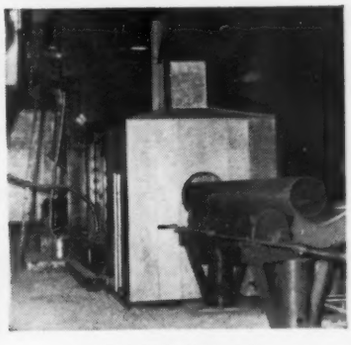


Control board of schedules in Plant Office

Skilled workmen throughout the plant of Standard Pipeprotection Inc. see to it that your pipe is coated and wrapped precisely according to your specifications. Adequate control of every step of processing results in your pipe starting to its destination exactly on schedule.



Coating and wrapping machine



Steel grit clean pipe ready for primer

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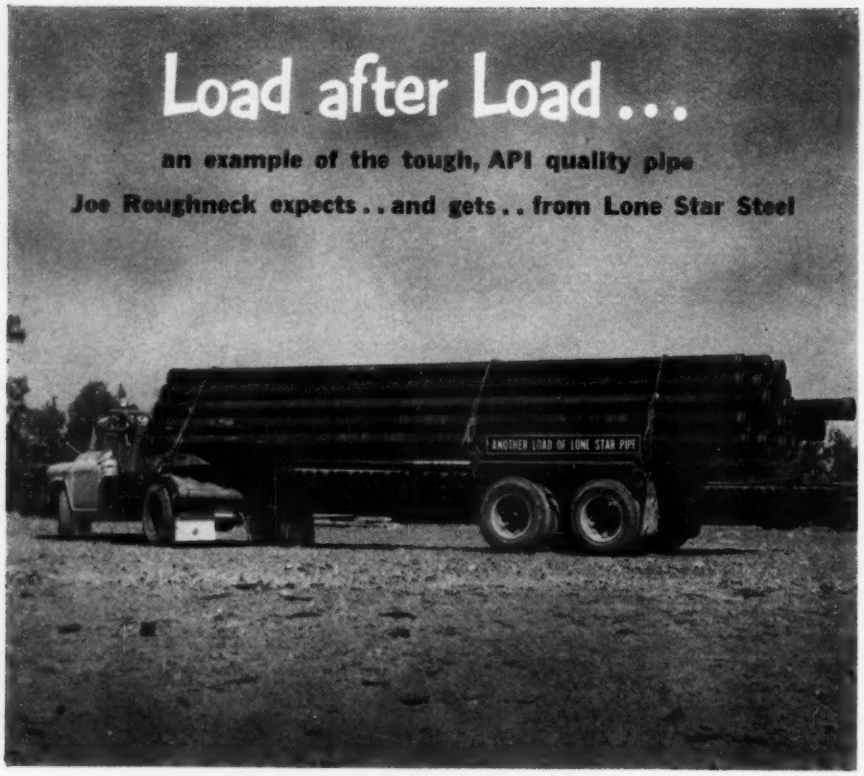
Load after Load . . .
an example of the tough, API quality pipe
Joe Roughneck expects . . and gets . . from Lone Star Steel
ANOTHER LOAD OF LONE STAR PIPE

In the heart of the oil country, Lone Star Steel's huge plant is Joe Roughneck's solid source of supply for API casing, tubing and line pipe. Quality-controlled from mining of ore to finished pipe . . Lone Star electric weld pipe meets strict API specifications. Fully normalized, of course.

Crossing rivers, bending over hills and rugged terrain is routine for Lone Star line pipe.

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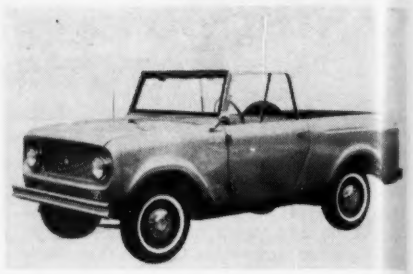

Scout . . . a new, small all-purpose vehicle designed for low cost transportation of passengers and cargo . . . has been introduced by motor truck division of International Harvester Co. Available in 2- or 4-wheel drive models, the *Scout* includes a 3-person passenger compartment with removable steel top, 5-ft long pickup body, fold-down windshield, removable door glass, removable doors, and a new International Comanche 4-cylinder economy engine as standard equipment. Suggested retail price of 2-wheel drive is $1598 . . . of 4-wheel drive, $1948. 5

New crawler-type trencher-backfiller . . . billed by its manufacturer as capable of digging straight as a string and backfilling quick as a cat . . . is now available from Davis Mfg. Inc. New features that enable unit to operate in severe digging conditions include: rugged, heavy-duty boom; built-in, pre-loaded boom shock absorber to cushion digging impact without power waste; and freeze-free auger mounting. Unit is built to handle broad scope of assignments in 9 out of 10 utility trenching jobs, has a digging range from 12-in. wide, 30-inches deep, to 3- and 4-inches wide, 66-inches deep, and varying widths and depths in between. 6

Newly-designed pilot for water heaters is believed to assure trouble-free performance by combining best features of incinerator and target-type pilots. Pilot provides superior flame stability and excellent nonlinting characteristics. Has no shutters, lint screens, or supplementary shields that require assembly or adjustment. Designed with self-compensating action in respect to primary air injection, pilot is able to operate over extremely wide range of gas pressures; this is said to eliminate need for pilot gas regulation. 7

All bolts-on-top is feature of new full-circle clamp coupling from Smith-Blair. Special lug design and alternating bolt arrangement give clamp high mechanical strength, and greater sealing power. Fits all common sizes of cast iron and steel pipe through 8-in. Other features include recessed armor and finely gridded gasket to give permanent leak protection, and double-radius head heat-treated bolts. 8

POSITION AVAILABLE

Experienced Natural Gas Distribution System Operator

Gas manager position available to qualified person in prosperous Iowa community. Six to eight years experience required in gas distribution system operation, maintenance, appliance adjustment and inspection. Position will require control of gas loads, meeting public as cities gas representative and manager, and other management and inspection duties.

Address replies and resume of qualifications to
CITY CLERK, Osage, Iowa